PRAMMER

Prammer Josef – Handmade Morta Smoking Pipes

Dear pipe smoker,

some years ago I started experiments on sub fossil oak wood according to the ability to absorb moisture and about the heat conductivity because I always have been fascinated by the smoke quality of this wood. Furthermore I asked an analytical chemist to analyse this wood. I was astonished by the amount of minerals which were enclosed in certain samples.

During the last years many pipe makers started to make pipes out of sub fossil oak wood of inferior quality. These pipes are likely to burn; they are stained dark or even varnished and have bad smoking characteristics.

Therefore I decided to instruct the following study. I hope that this study can provide you an insight into the different quality criterions which are important for pipes out of sub fossil oak wood.

Yours Josef Prammer

Prammer Josef

PRAMMER BOKU

The suitability of sub fossil oak wood to build pipe bowls

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Aim of the project

Aim of the project was the scientific evaluation of sub fossil oak wood to build pipe bowls. Due to the experiences of Mr. Prammer using bog oak wood for pipes, a pre-selection of wood samples – in the meaning of suitability – was done. The light coloured (light brown) samples are not as good as the darker ones. The relationships between different wood scientific parameters and the suitability to build pipe bowls should be studied. With the help of these results, it will be possible to determine the suitability of raw wood boards to produce pipe bowls.

The pipe

In the bowl of the pipe the tobacco is glowing. The emerging smoke is gathered through a mouth-piece (pipe) into the mouth. The formation of smoke takes place at the glowing area in the bowl.

The material of the pipe (especially the material of the bowl) has a great influence on the taste of the smoke as well as on the suitability of the pipe itself. On the one hand, the wood has to be stable against heat (it's not allowed to burn) and on the other hand it has to absorb moisture from the tobacco during glowing. A bad taste due to the wood of the bowl is not welcome. The most usual material to produce pipe bowls is "Bruyère", which originates from the rot tuber of *Erica arborea*, growing in the Mediterranean region. High-value wooden species like cherry-tree, olive-tree or oak are also used.

The sub fossil Oak wood

Sub fossil oak (or bog oak) is oak wood which was buried in a very moist environment, like in gravel or bogs. Usually such condition occurs after catastrophic events like flooding or storms.

In soil as well as in groundwater, iron-ions are available in different concentrations. The well known reaction of iron with the tanning agents, which are situated within the oak wood, changes the colour of the oak wood to dark grey - black or dark brown. The colouration is not consistent over the whole cross section. The light coloured sapwood is, due to the burying or due to microbial decay, usually eroded.

Depending on the condition of the bedding, a different degree of degradation of the wood takes place. This degradation starts when a tree was felled (or was broken down), or in certain cases also during the growth of the tree. This can be a reason for a strong difference in the quality of the bog oak wood. When the oak tree begins dying, the degradation of the wood starts immediately. If it takes long before a dead tree is embedded, a strong degradation is resulting. If a living tree gets buried (due to flooding etc.) the conservation in water starts immediately, resulting in better wood quality of the sub fossil oak trunks. The anaerobe, microbial degradation under water (or at least in humid environment) is very low.

These slow degradation processes are not well described in literature; also inconsistent data are possible (Rowell und Barbour 1990). In the first instance hemicellulose and cellulose gets degraded, while lignin is stable for a longer time. At the same time higher ash-contents are described, which can be attributed to the inclusion of mineral substances. The changed chemical composition – organic as well as in-organic – alters the ability to absorb water.

The age of bog oak trunks can differ from several hundred to thousands of years. Wagenführ and Scheiber (1985) described the characteristics of the wood as following:
Oven dry density: 0,58 to 0,73g/cm³; density 0,62 to 0,76g/cm³, moderately shrinkage; Hardness, density and mach inability differs with place of burial and age.
The bog oak wood is easy to saw, plane, mill-face, drill, veneering, sanding and turning. It is not weather-resistant and rather moderate stable to fungi and insects.

Material

Ten different raw-samples of unknown age were used for the tests. They originate from Middle-Europe, mainly from Austria (see Fig. 1). Bruyère was tested as reference material. Most of the samples were classified as usable to produce pipe bowls.

Figure 1: scanned surface of the 10 bog oak samples

Not all described tests were done at all samples. Mainly, the samples with a good ability to produce pipe bowls were tested. Especially at the determination of the age, restrictions of the quantity of samples were necessary.

Methods and results

During stuffing and smoking a lot of changes within the wood of the pipe-bowl are taking place. These changes have a strong influence on the ability to use the wood for pipes and furthermore on the quality of smoking. Different tests which describe the changes in the wood during the stuffing and the smoking were chosen. The tests started with the identification of the age of the wood and the wood density. The equilibrium moisture content, the water uptake and the swelling are describing the chemical condition of the wood and the affinity to water. The increased affinity to water is due to a changed amount of the degree of crystallisation of the cellulose. During the degradation, the amount of amorphous parts of cellulose could be increased, which makes it easier for water-molecules to access the wood. Characteristics like swelling and shrinkage are important for the stability of the bowl during stuffing and smoking. The chemical analyses present the inorganic composition of the wood; i.e. the amount of ions which were introduced during the buried period.

Determination of age with the help of Carbon-14

The determination of age (sample number 1 to 4) was done at the University of Vienna, Vienna Environmental Research Accelerator (VERA), Prof. Wild (see tab. 1). The age varied between 1300 and 5000 years.

Nr.	sample Nr.	age, calibrated	2 σ confidence interval (%)	age (years)
1	VERA-4602	2940-2860BC	86.0	4900
2	VERA-4603	650-820AD	94.2	1280
3	VERA-4604	240-420AD	95.4	1690
4	VERA-4605	3090-2890BC	95.4	5000

Table 1: Carbon-14 dating of the four samples (BC = before Christ; AD = ano domini)

There is no strong relationship between the scanned surfaces (Fig. 1) and the age (Tab. 1). The colour seems to be dependent on parameters like the condition during burying.

The smoke ability

The smoke ability, which means the ability to use the raw material, was classified by Mr. Prammer following ~~the~~ school grades; 1 = excellent; 5 = insufficient (see Tab. 2).

sample	1	2	3	4	5	6	8	9	10	11
smoke ability	1.0	1.5	2.0	1.0	1.0	4.0	2.5	5.0	5.0	2.5

Table 2: Smoke ability of the different samples

Ranking the samples according to their intensity of colour, it's obvious, that light-coloured samples are related to bad smoking conditions (see Tab. 3).

sample	1	4	5	2	3	8	11	6	9	10
smoke ability	1.0	1.0	1.0	1.5	2.0	2.5	2.5	4.0	5.0	5.0

Table 3: Smoke ability, ranked with school grades

The used reference – Bruyère – is described as species with good characteristics

Wood density

The wood density is one of the universal wood quality parameters. The wood density is strongly related to various characteristics. For the sub fossil oak it is also a measure of the degree of degradation.

Wood density was determined as oven dry density (wood density of completely dry wood) and as wood density at an equilibrium moisture content at the standard climate (20°C, 65% relative humidity resulting in approximately 12% moisture content).

The results of the oven dry density show a strong variation between 0,62 und 0,86 g/cm³. Wagenführ and Scheiber (1985) presented density values between 0,58 and 0,73 g/cm³. The reference (Bruyère) had a density of 0,77 g/cm³ (see Fig. 2).

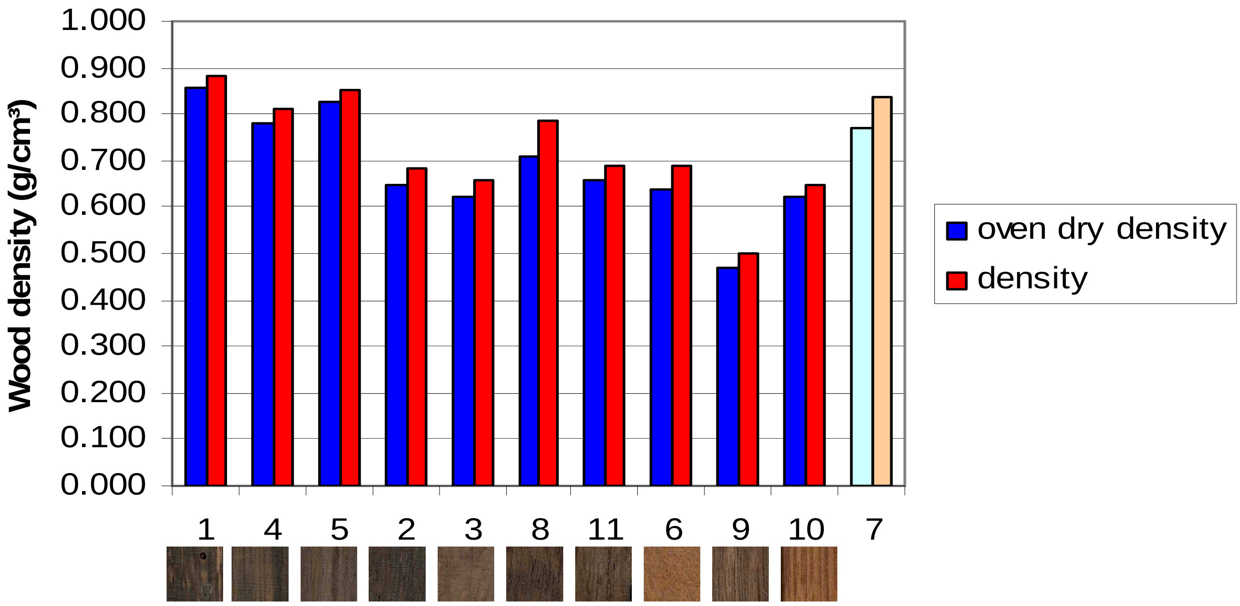

Figure 2: Oven dry density (blue) and wood density (at 12 % moisture content; red) of the samples; sorted by the smoke ability. The sample 7 is Bruyère.

A strong relationship between density and smoke ability is visible: A high wood density is necessary to produce high quality pipe bowls (Fig. 3).

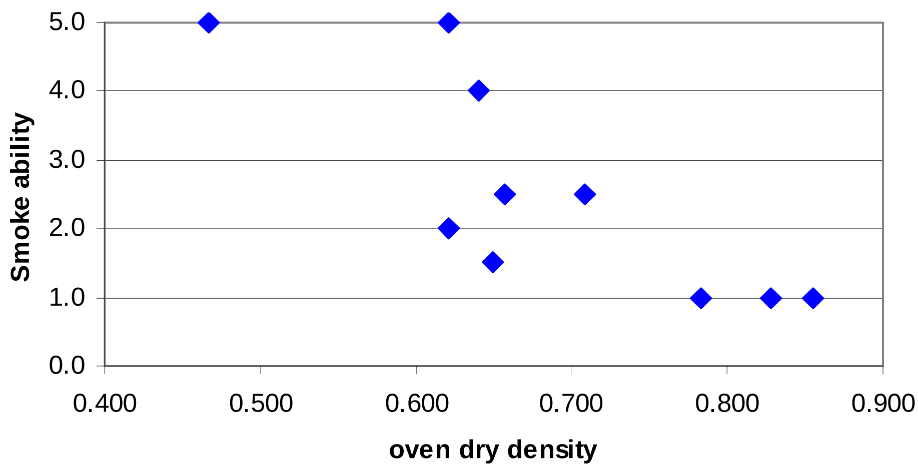

Figure 3: The relationship between smoke ability and oven dry wood density (without sample 7).

Equilibrium moisture content

Storing wood under a given constant climate, the samples reach given moisture content. The samples were stored under standard climate (20°C, 65% rel. humidity) for several weeks. Spruce wood reaches under such conditions 12% moisture content. Deviations can occur due to changes in the chemical composition.

The measured values varied between 10,6 and 13,5% (see Fig. 4). There is no relationship between this parameter and the usability.

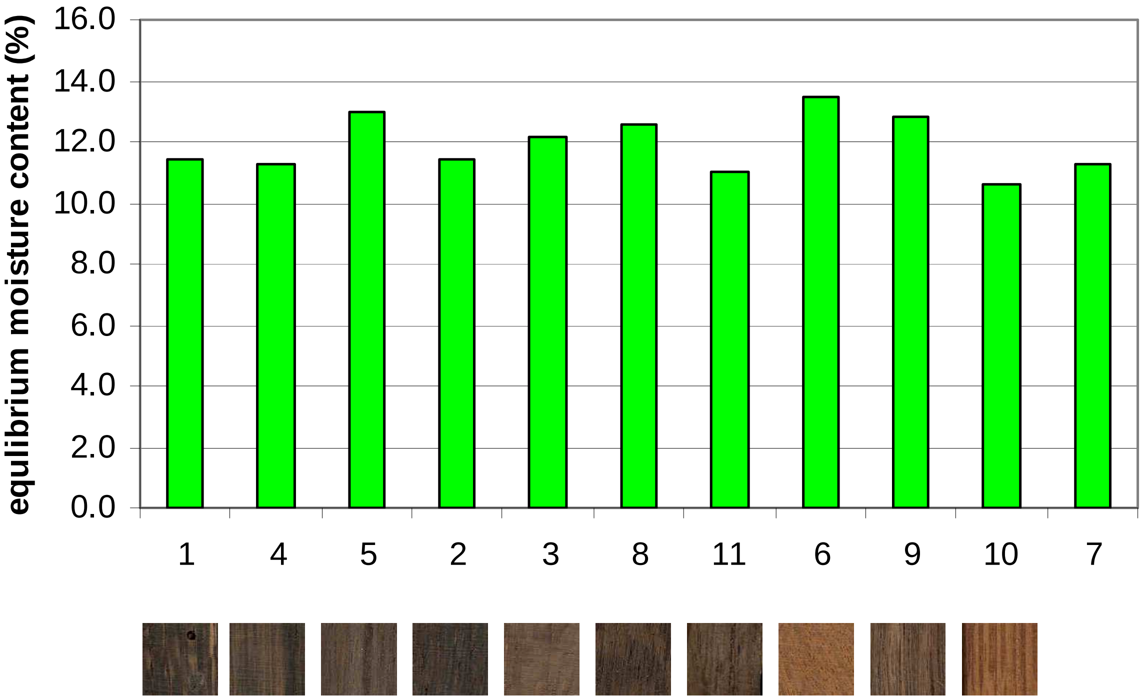

Figure 4: Equilibrium moisture content of the samples (sorted by the smoke ability); 7 = Bruyère

The swelling

Due to the hygroscopic behaviour of wood, moisture from the air can heighten the moisture content of the wood. Below the so called fibre saturation point (about 30% of moisture content; the cell walls are saturated with water, but there is no liquid water in the holes of the cells) ongoing drying processes cause shrinkage of the wood. If the wood gets moistened again, it swells in the same relation like the shrinkage occured.

The three anatomical directions of the wood differ in swelling and shrinking. In tangential direction it’s twice than in radial direction. The proportion between longitudinal : radial : tangential is 1:10:20.

Due to the highest values, the tangential swelling coefficient was chosen. Wagenführ und Scheiber (1985) reported about values of 6,9 to 14,2%. Due to sometimes not perfectly orientated samples the volumetric swelling coefficient was also calculated .

The values of the tangential swelling varied between 3,8 and 7,4% (see Fig. 5), which is lower than described in literature. These low values are caused by the general high variability of this parameter, as well as by the fact that the samples were not perfectly oriented. Bruyère is not growing in aligned directions like wood. Therefore a comparison is not possible.

There is a weak tendency of high values at samples with good smoke ability.

The results of the volumetric shrinkage (Fig. 6) confirm the trends seen at the tangential swelling coefficient. Basically you can see that samples with higher swelling coefficients are more suitable for smoking.

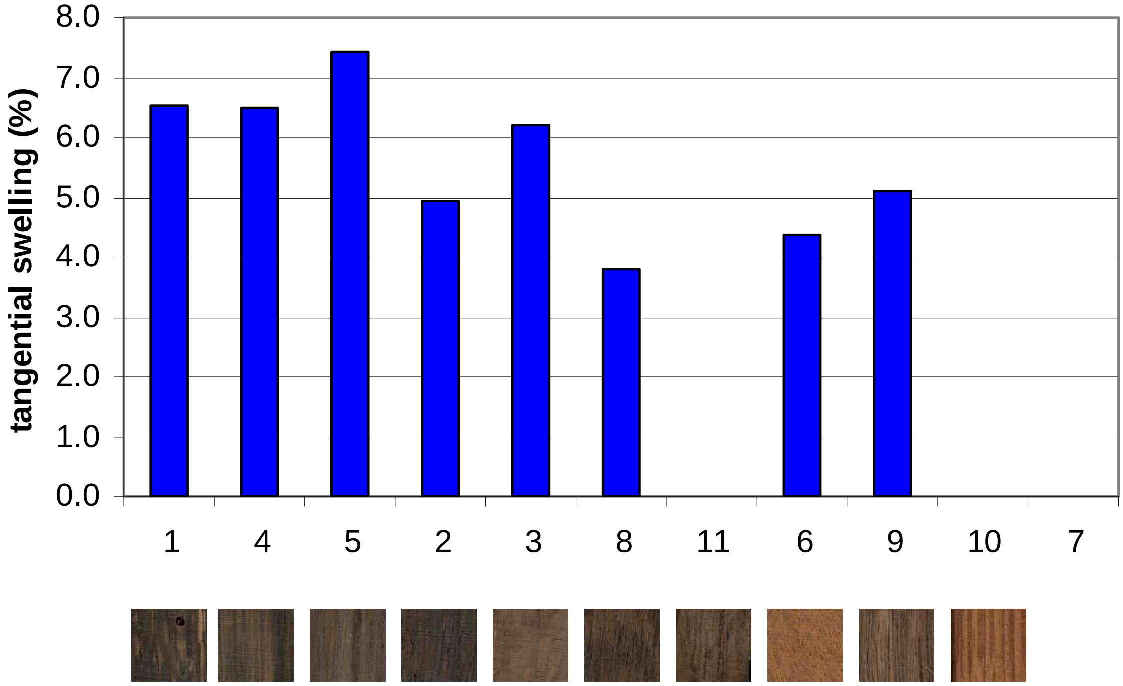

Figure 5: Tangential swelling of the samples (sorted by the smoke ability)

Reduced swelling coefficients are usually a hint of a "modification" of the wood, which happens also at the steaming of wood. Changes in the organic chemical composition (cellulose, lignin, hemicellulose) reduce the swelling coefficient as well. There is a strong relationship between density and swelling. That means, if density and chemical composition is reduced – due to degradation of the wood – also the swelling becomes lower.

Moisture Absorption

The ability to absorb water is important for the bowl of a pipe. During the smoking the wood has to absorb water from the tobacco.

We tried to simulate this process. Oven dry samples were stored above liquid water for 20 minutes (there was no contact to the water). The samples were weighted prior and after the test and the water uptake was calculated.

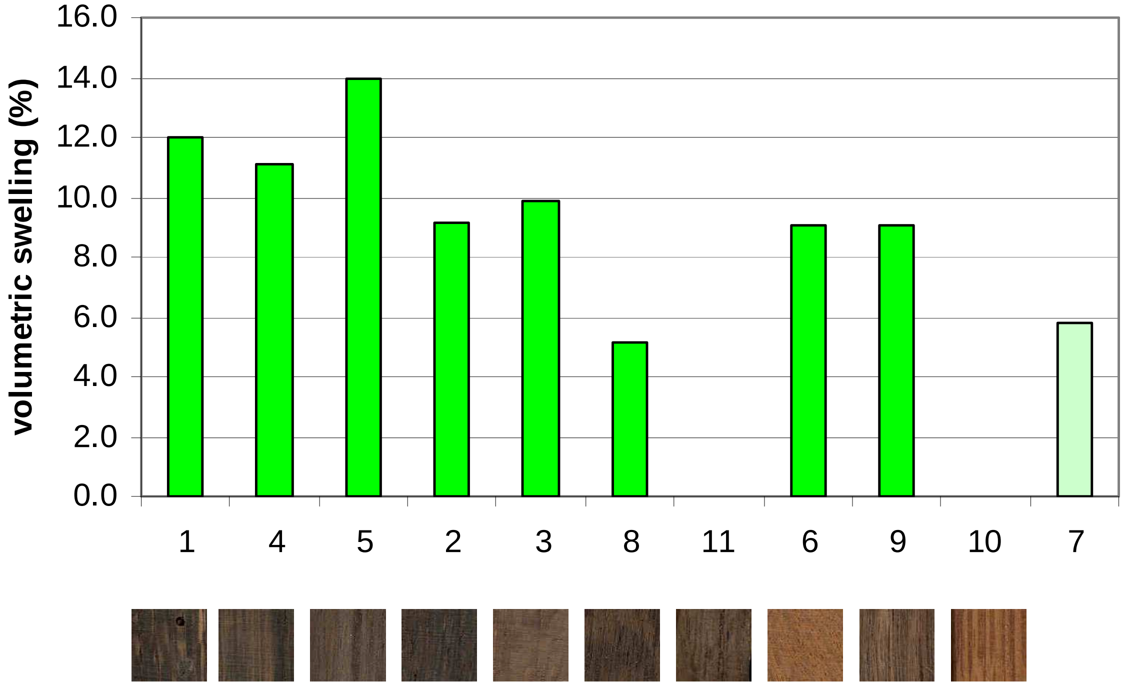

Figure 6: Volumetric swelling of the samples (sorted by the smoke ability; 7 = Bruyère)

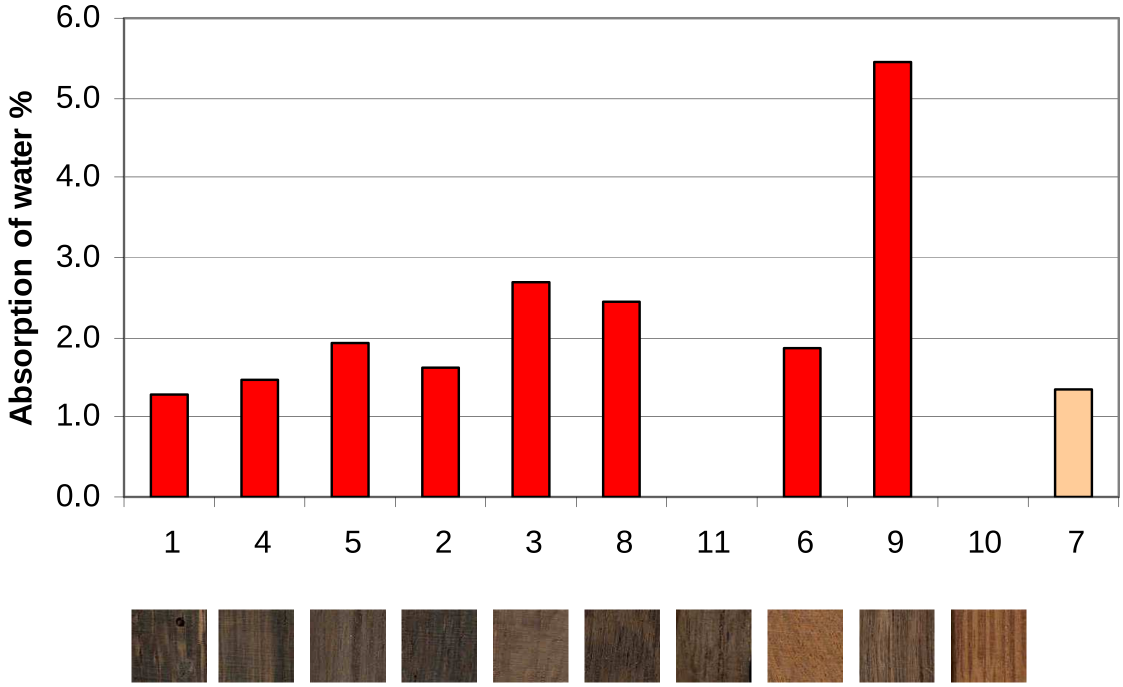

Figure 7: Absorption of water (sorted by the smoke ability; 7 = Bruyère)

Figure 8 shows, that there is a relationship between water uptake (within 20 minutes) and suitability of the wood to build pipe bowls. The best samples take up less water then the worst. The amount of water absorbed by samples with the best smoking qualities is the same like for Bruyère.

This parameter seems to be also a hint of the organic chemical composition of the wood (degree of degradation).

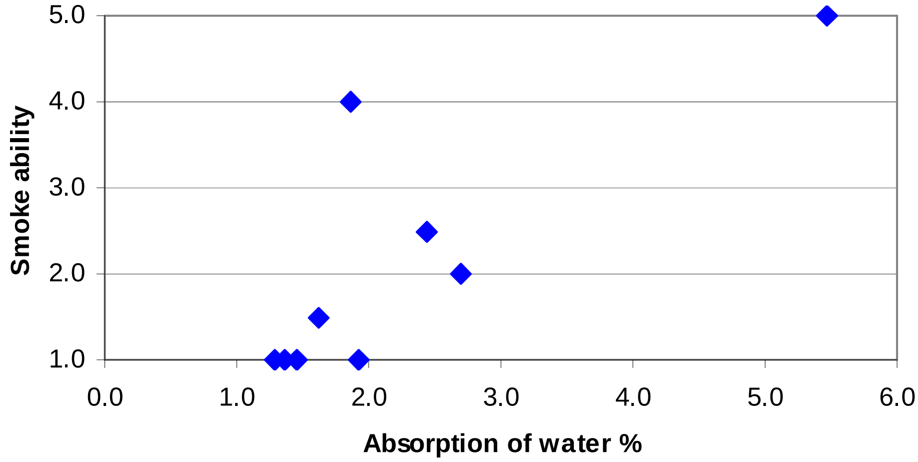

Figure 8: The relationship between the smoke ability and absorption of water in 20 minutes (without the samples 7, 10, 11).

The amount of ash

The determination of the amount of ash:
One to two grams of dry wood were getting to ash in an oven at 700°C. At the first part of the oxidation, the pot was closed to ensure, that no ash is going to loos during the intensive burning of the carbon. After one hour the pot was opened, and stood inside the oven for three more hours. After cooling the mass loss was determined (see also Fengel and Wegener 1989). At least two determinations per sample were done.

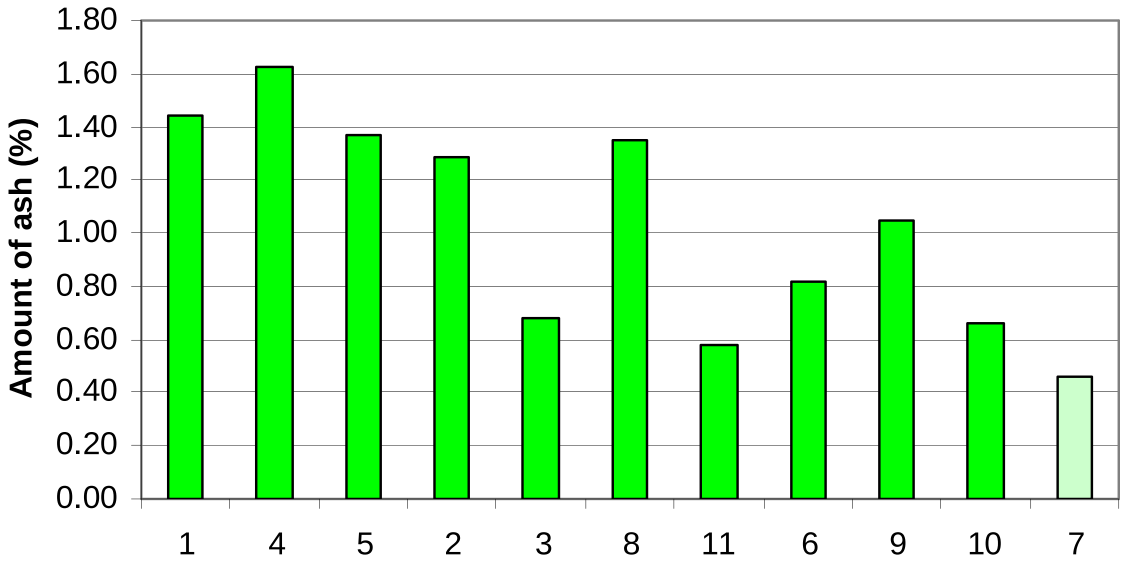

Figure 9: Amount of ash (sorted by the smoke ability; 7 = Bruyère)

When you measure the amount of ash you can derive the amount of inorganic substances (mainly salts) within the wood. Wagenführ and Scheiber (1985) mentioned an amount of 0,8% for sub fossil oak. The determined values were between 0,5 and 1,6% (see Figure 9), which meets the descriptions of literature.
The amount of ash in fresh oak wood is 0,2% (Wagenführ and Scheiber, 1985). The higher values of the sub fossil oak are due to inclusion of salts during the time of burying.

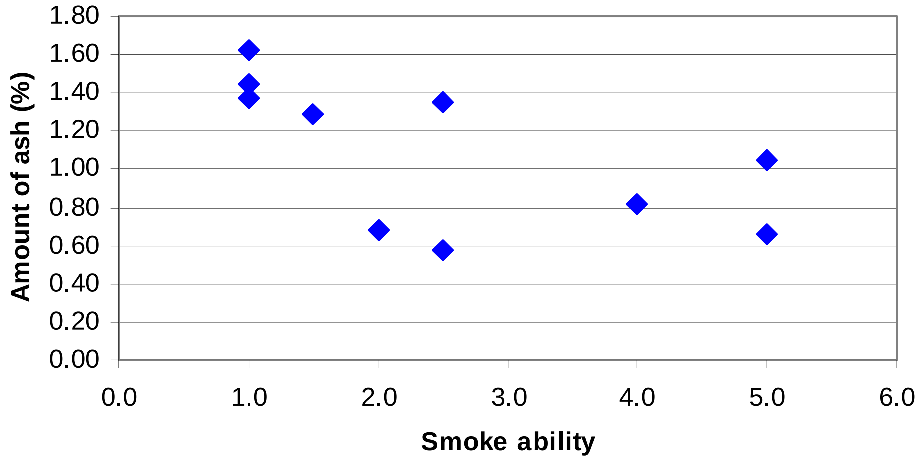

Figure 10: The relationship between the smoke ability and the amount of ash (without the sample 7).

In the figures 9 and 10 it's well visible, that there is a strong relationship between smoke ability and amount of ash. Samples with good smoke abilities had high amounts of ash.
There is a strong correlation between colour of the wood and suitability to build pipe bowls. Due to these relationships it seems, that the reaction of iron and the tanning agents of the wood is responsible for the dark colour of the wood.

Amount of inorganic elements

Determination of the amount of inorganic elements:
The samples were dried for 48 hours at 40°C and 80 mbar in a vacuum oven. 500 to 700 mg of the dried samples were used for the analyses.
A high pressure microwave digestion was chosen, which was done with the agents: 0,5 ml 30%igem H_2O_2, 1ml 70%iger $HClO_4$ and 6ml conc. HNO_3. A program with different heating and cooling phases was chosen. After 35 minutes of digestion and cooling, the liquid was filtered and purified water was added up to 50 ml. The qualitative and quantitative analyses were done with the help of a flame AAS (Atomic Absorption Spectroscopy) and ICP-OES (Inductive Coupled Plasma Optical Emission Spectroscopy).

The following elements were determined:

Sodium, Potassium, Iron, Calcium, Magnesium, Zinc, Copper, Chrome, Manganese, Nickel and Aluminium.

Nr	smoke ability	ash	sodium	potassium	Iron	calcium	magnesium	zinc	copper	chrome	manganese	nickel	aluminium	sum
		%	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g
1	1	1.45	0.10	0.12	4.51	4.01	0.62	0.00	0.01	0.00	0.12	0.00	0.04	9.53
4	1	1.63	0.06	0.05	9.18	3.71	0.28	0.01	0.01	0.00	0.25	0.00	0.03	13.58
5	1	1.37	0.02	0.01	3.60	4.40	0.30	0.00	0.01	0.00	0.07	0.00	0.02	8.43
2	1.5	1.29	0.03	0.05	3.84	3.51	0.36	0.00	0.01	0.00	0.09	0.00	0.02	7.90
3	2	0.68	0.09	0.05	0.89	3.22	0.40	0.02	0.01	0.00	0.05	0.00	0.03	4.76
8	2.5	1.35	0.17	0.09	1.37	4.20	0.33	0.00	0.02	0.00	0.01	0.00	0.04	6.24
11	2.5	0.58												
6	4	0.81	0.05	0.05	0.02	6.85	0.46	0.00	0.01	0.00	0.01	0.00	0.03	7.48
9	5	1.05	0.07	0.03	1.27	3.72	0.30	0.00	0.01	0.00	0.01	0.00	0.02	5.44
10	5	0.66												
7	1	0.46	0.07	0.89	0.01	0.32	0.20	0.00	0.01	0.00	1.57	0.00	0.00	3.09

Table 4: Amount of ash and elements (sorted by the smoke ability)

Table 4 presents, that just the elements iron, potassium and magnesium show high values. Fengel and Wegener (1989) described potassium and magnesium as the most frequent elements in wood. They play an important role during wood formation.
So, the values of iron are the most interesting ones for sub fossil oak.

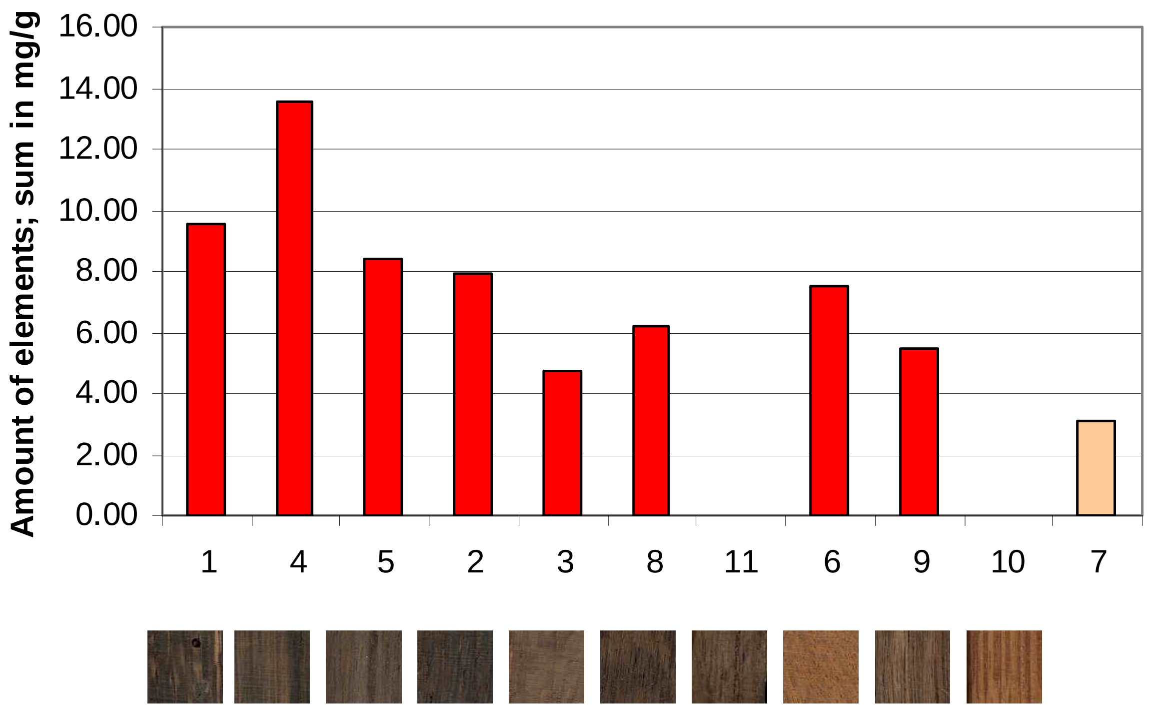

Figure 11: Amount of elements (sum) (sorted by the smoke ability; 7 = Bruyère)

The sum of elements shows interesting relationships to the smoke ability (see Fig. 11). A good suitability to produce bowls is connected with high amounts of elements. The sum of elements correlated well with the amount of ash. Therefore it can be assumed, that all important elements have been determined. Just silicates could have been included at some of the samples.

The sum of elements is lower than the amount of ash. This fact is probably based on the missing determination of anions. Metals can be found as oxides in the ash, which is not the case in the natural condition of the wood.

Primarily iron, potassium and magnesium play a role for the sum of elements (see Table 4). Because of the high impact of potassium and magnesium on the formation of wood, iron was presented alone (Figure 12).
The reaction of iron with tanning agents of the wood is responsible for the dark colouration of the sub fossil oak wood. This reaction is also described for fresh oak wood (Fengel and Wegener, 1989).

So, the colour (dark brown, dark grey up to black) is strongly influenced by the amount of iron in the surrounding environment, where the trunks were buried over hundreds of years. The dark colour can be modified by degradation (especially microbial) of the wood – getting brighter again. To split and quantify these processes in the meaning of colour is not possible due to state of knowledge.

Figures 12 and 13 present the strong relationship between the amounts of iron and the smoke ability. The darker wood samples have higher amounts of iron and are better to produce pipe bowls. That's also a confirmation of the high importance of the reaction between iron and the tanning agents on the colour of the wood.

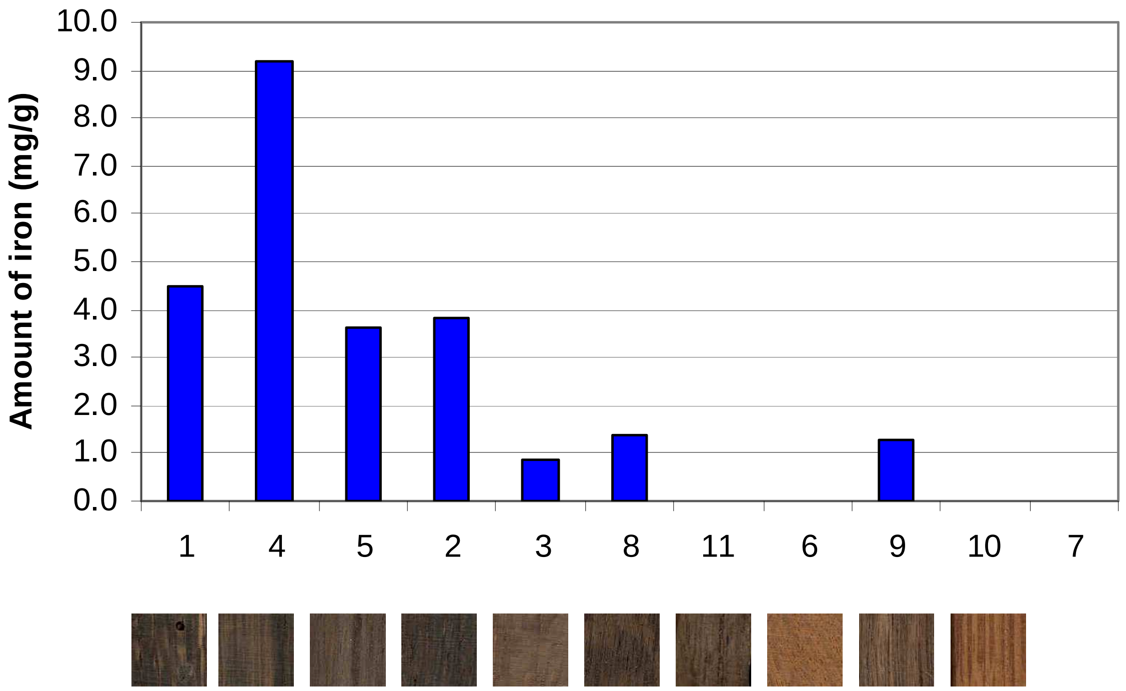

Figure 12: Amount of iron (sorted by the smoke ability; 7 = Bruyère)

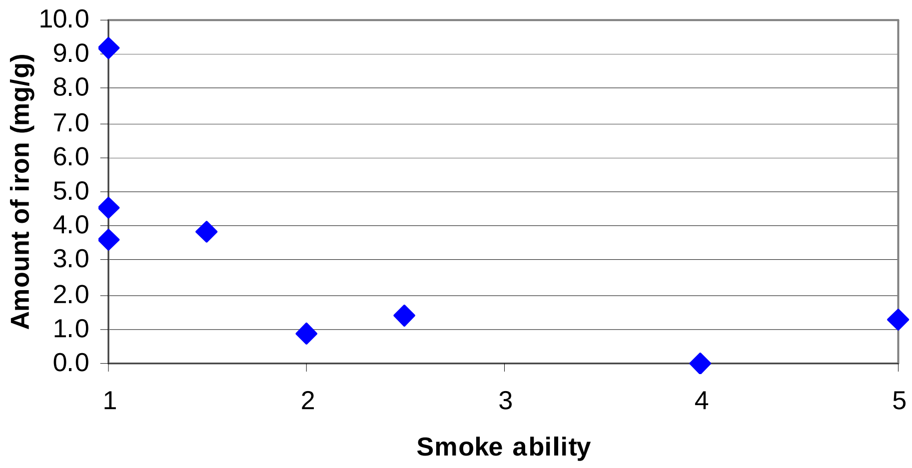

Figure 13: The relationship between the smoke ability and the amount of iron (without sample7).

Abstract and conclusions

Under wet conditions wood can be preserved thousands of years. Sub fossil oaks can be found in the gravel of rivers as well as in bogs. Under anaerobic conditions just a slow microbial degradation of wood takes place (Rowell und Barbour 1990). If these conditions do not always exist, a degradation of the wood caused by fungi and mold can occur. These processes can also take place at standing trees, prior the burial processes.

So, the quality of the sub fossil oak wood can vary greatly. This project was established to find possibilities to determine the suitability of different origins of sub fossil oak to produce bowls of pipes in advance.

The age of these buried oak trunks varies greatly. The radiocarbon dating presented an age of 1300 to 5000 years. This enormous difference in age does not influence the suitability and the colour. It's not possible to estimate the age with the help of the colour.

The most important parameter, which is connected to the suitability to produce pipe bowls, is the degree of degradation and the chemical properties.

Various parameters confirmed this statement:

- The colour presents a strong relationship to the smoke ability. The darker coloured samples (dark grey up to black) are better applicable. The dark colour is linked to the reaction of iron and tanning agents, which is mainly described for oak wood.
- The wood density has to be high to produce good bowls. The highest value was 880kg/m³, which is higher than cited in literature (615 – 760 kg/m³). The wood density of oak wood varies between 430 and 960 kg/m³ (Wagenführ and Scheiber 1985). A

high wood density of the living oak tree and good preservation can be attributed to the high density of the sub fossil oak.
- Swelling and water uptake are linked to the condition of the sub fossil wood. These parameters can be altered especially by changes of the organic-chemical composition of the wood. Wood with good qualities to produce bowls has high coefficients of swelling and reduced potential of water uptake. The highest values of tangential swelling of sub fossil oak wood are comparable to the values of fresh oak wood.
- There is a strong relationship between the amount of ash and the smoke ability. A good suitability is linked with a high amount of ash.
- The amount of elements – especially iron – is high in samples of good suitability. As these samples are dark coloured, it might be linked with the reaction of iron and tanning agents.

Concluding, the best qualities to produce pipe bowls have to be of high density and dark colour.

Michael Grabner, January 2009

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