Erica Orr Winemaking Consulting
ericaorr@gmail.com
(925) 212-9979

# Oak Background

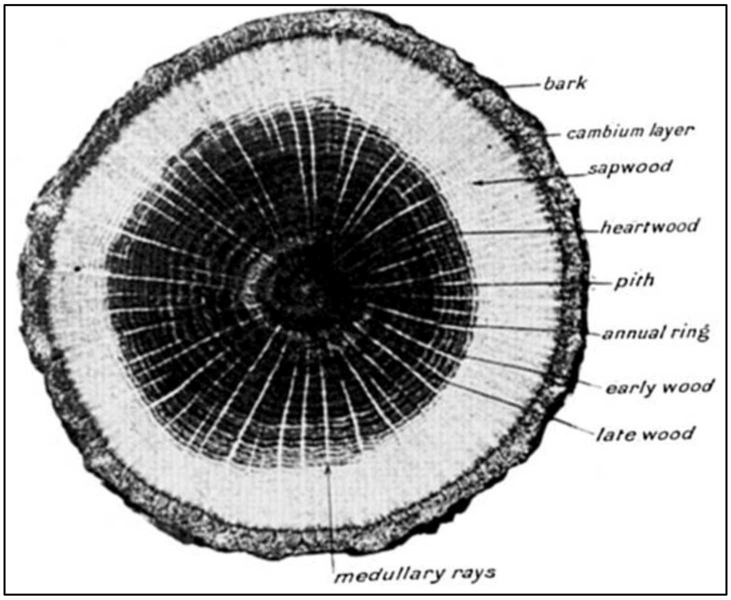
**Why make wine barrels out of oak?**
Botanically, the Oak genus constitutes more than 400 species.
White Oak has special characteristics that make it perfect for wine barrels

1) HARDWOOD -- It's a hardwood, meaning white oak is generally resistant to decay and fungal and insect attack. Oak wood is strong and durable and although it is hard, it is easy to bend and generally workable.
2) DELICIOUS AROMAS -- Oak is naturally aromatic and not resinous like cypress, fir or eucalyptus
3) LOW RATE OF SHRINKAGE -- White oak has a lower rate of shrinkage meaning that a barrel can stay water-tight under the alternating wet and dry conditions of winemaking.
4) GROWS SLOW AND STRAIGHT (WITHOUT WARPING) -- White oaks grow as large straight-grained trees without a real tendency to warp. In general, a larger, mature and thus slower growing tree will have more usable wood and higher extractives.
5) BOTANICALLY UNIQUE -- The most important features of white oaks for water-tight barrel making are the medullary rays and tyloses.

Some useful definitions:

*Medullary Rays*

Medullary rays are perpendicular to the growth rings. It is an impervious thin barrier that goes along the radius of the trunk cylinder from the pith to the bark in all trees. Hardwoods (including oak) have wide medullary rays which significantly contribute to hardwood's strength and flexibility. The medullary rays also prevent liquid from penetrating through the structure of the wood.




*Tyloses*

In the sapwood (the outer edge of the tree where growth occurs) there are large pores that are open to transport fluid between the roots and the leaves. White oak is unique both relative to other oaks and other hardwoods because when the living sapwood transitions to dead heartwood, the pores are blocked by what are called tyloses. It is for this reason that only 20 of the 400 species of oak are water-tight for barrelmaking.

Erica Orr Winemaking Consulting
ericaorr@gmail.com
(925) 212-9979

# Oak Sources

**American Oak *(Quercus alba)***

A different species of oak than grown in France, American oak has more oak lactones and more vanillin compared to French oak. It has a tight grain and is more water-tight which allows it to be sawn into staves instead of split. This is one of the reasons why American oak barrels are less expensive than French.

**French Oak *(Quercus sessilis*)**

**Center of France –** medium-tight grain 14-15 grains per inch

**Nevers oak –** from Nievre Département in the center of France. Trees grow tall and straight in forest conditions producing timber which is medium-tight grained (14 -15 grains per inch). Includes Bertranges forest.

**Bertranges oak –** is from a specific forest within Nevers

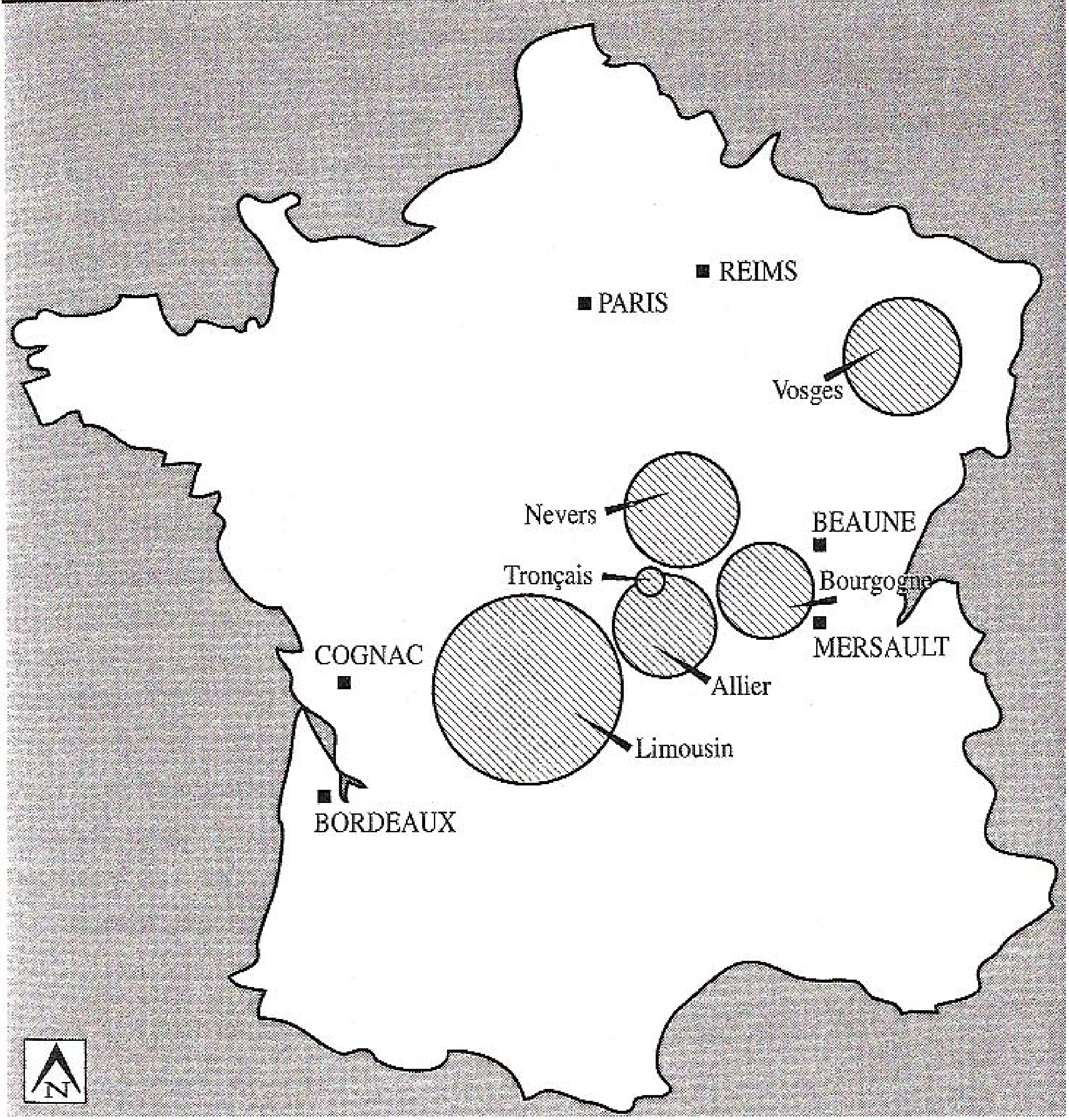
**Allier oak –** This comes from forests south of Nevers but is also considered Center of France oak. The oak is very similar to that of Nevers with slightly tighter grain (15-16 grains per inch). Includes GrosBois and Tronçais forests.

**Tronçais oak –** comes from a specific forest within the Allier Département. It is the most famous of the forests deliberately planted in the late $17^{th}$ century to ensure a continuing supply of oak for the French Navy. The forest is apparently “spectacular” and the soils are deep and fertile producing trees of great size. The grain is fine and long and very tight (16 -17 grains per inch).

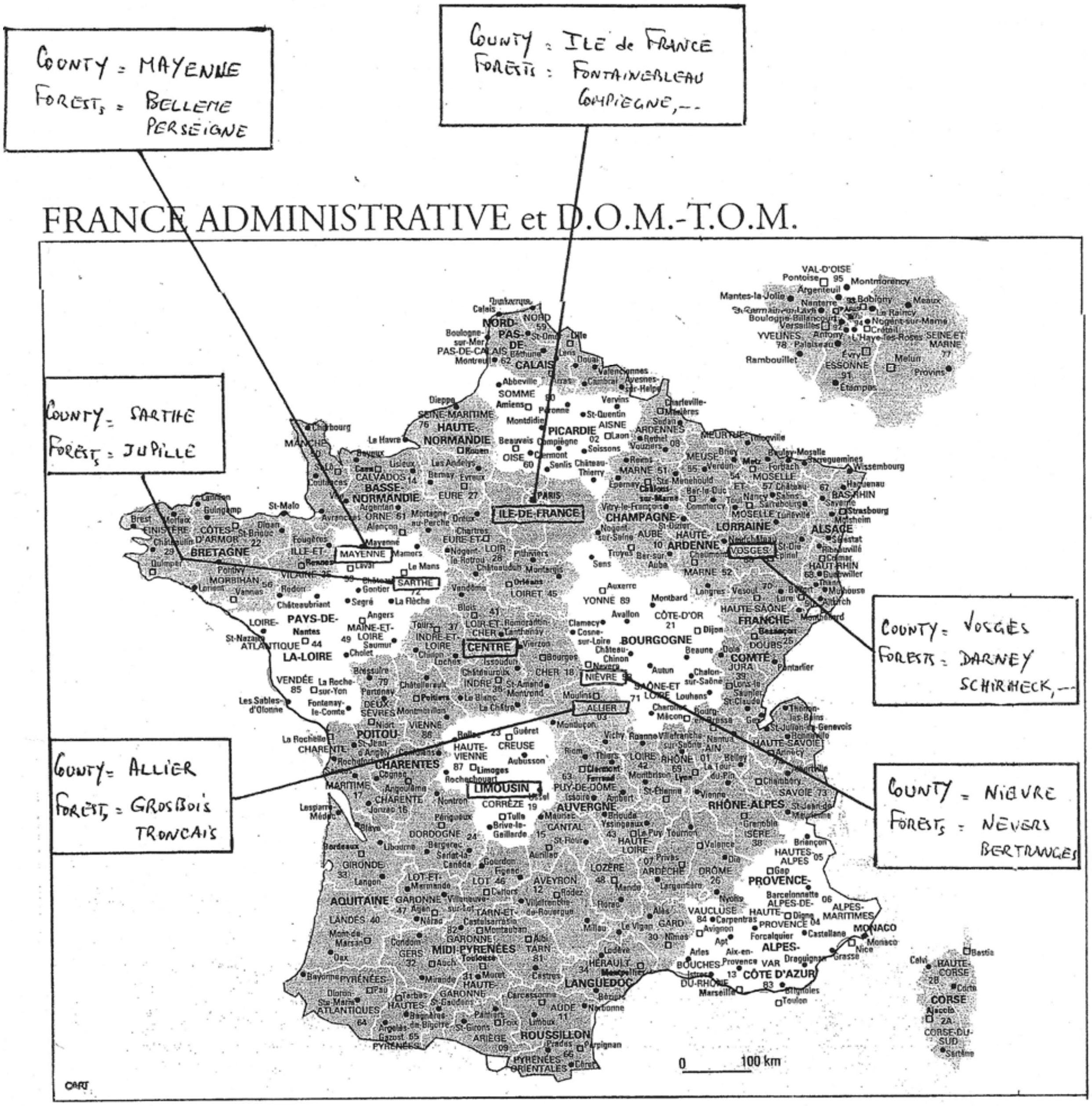
**Jupille oak –** comes from the west part of center of France in the Sarthe Département.

**Vosges oak –** comes from the mountain range in the north-east corner of France. The trees are tall with narrow trunks and the wood is medium grained (10-14 grains per inch)

# Principal Oak Producing Areas of France



Erica Orr Winemaking Consulting
ericaorr@gmail.com
(925) 212-9979



Erica Orr Winemaking Consulting
ericaorr@gmail.com
(925) 212-9979

# Wood Grain

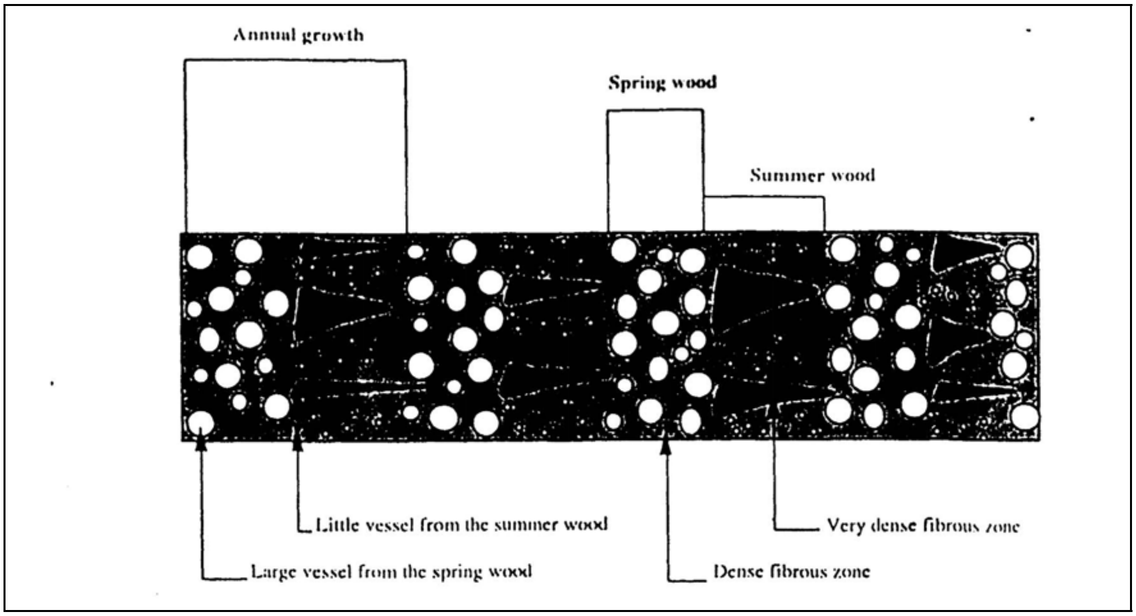



**Fig. 1.** Diagram of the grain structure showing spring and summer wood.

**Why is the Grain Tightness important?**
*The tighter the grain, the slower the extraction and the greater the oxidation.*

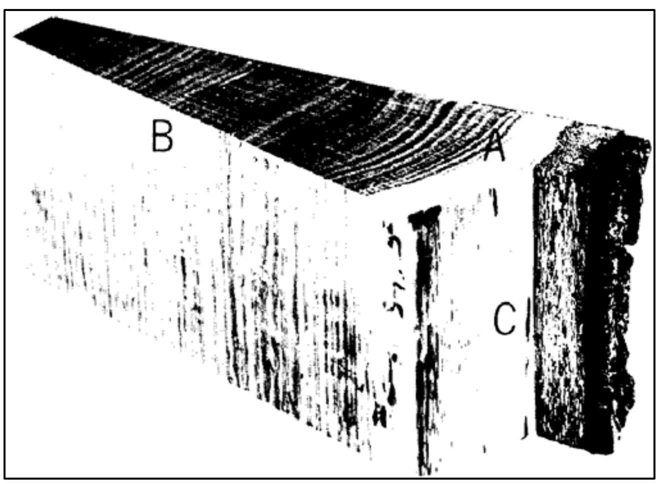



**Fig. 2.** Block of oak cut to show: A, the cross-section, B radial, and C tangential faces.

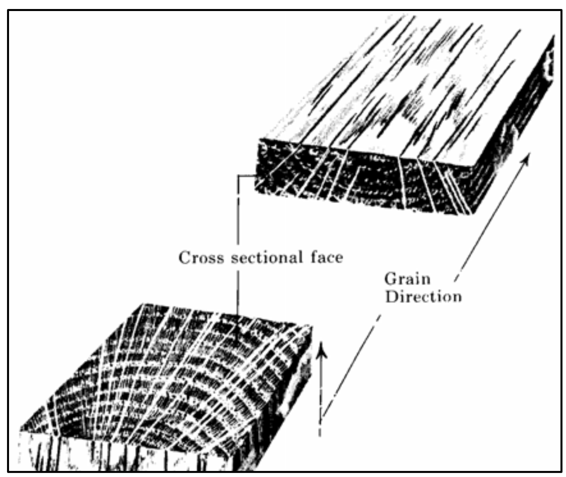



**Fig 3.** Plank of oak cut to show the grain running the length of the plank.

# Stave preparation

*Sawing* – is more economical, faster and with less waste (recovering 50% of usable timber from a log) compared to hand split wood. All American oak is sawn.

*Splitting* – is more expensive, requiring skilled labor and recovering only 20% of usable timber from a log. Because it follows the grain of the wood exactly, the staves are not always straight and can be more difficult for the cooper to handle. But because the stave exactly follows the grain, porosity is reduced. American oak is naturally less porous so it is better suited to sawing.

*Drying and Seasoning* – when first cut more than half of the weight of oak is water. During drying the oak shrinks until it reaches a point where the moisture content is in equilibrium with the moisture in the atmosphere surrounding it (8% in summer to 16% in winter, or higher in humid climates). If oak is used before it reaches its equilibrium moisture content it will shrink, the stave joints will open and the barrel will leak.

Traditionally oak is stacked so that air can circulate. The "seasoning" effect of rain is very important, washing out some of the harsh tannins and other unpleasant components which occur in newly cut "green" oak. It has also been shown that molds grow on the surface of the stave and physically break down some of the wood structure and biochemically break down some of the tannins. In addition, seasoning begins the process of degradation of lignins and hence the formation of the majority of the beneficial aromatic compounds, such as vanillin and eugenol.

*** What is the difference between 1, 2 and 3 year air-dried oak?*

# Barrel Making

## Cooper's influence – barrel assembly

After seasoning, staves are cut to the exact length (called docking). The next process is to plane the internal and external surface to a curve which matches the circumference of the finished barrel. This is called "backing and hollowing". The edges of the staves are very critical to prevent leakage – they are "jointed."
Then the staves are sorted and the cooper starts to build the barrel inside of a "rising hoop." Once the rising hoop is filled with staves more hoops are driven onto the assembly and it is ready for bending.

There are several ways to make the staves pliable. The whole assembly can be steamed in a steam chamber, the assembly can be immersed in hot water, or the assembly can be placed over an open fire and water can be splashed or sprayed onto the staves. These different techniques have aroma implications for the barrel.

After 12-15 minutes of steaming the assembly is ready to bend with a cable and winch.

Subsequent firing dries the moisture from the steaming out of the staves, and more importantly toasts the inside surface of the staves.

## Toasting from a chemical standpoint – the artistry of barrel making

If the fire is low heat, the heat will penetrate deep into the staves. If it is high heat it will char and blister the inside surface of a barrel to blackness with little penetration. Each cooperage has its own particular functional definitions of light, medium, medium plus and heavy toast based on time over the fire, the heat of the fire, temperature of the outside of the barrel, whether or not the lid is on top of the barrel as it is toasting, etc.

> *Light toast – has less caramelization and more harsh wood tannin, does not penetrate the surface of the wood*
>
> *Medium toast – some caramelization, better wood tannin integration with wine, penetrates 2mm*
>
> *Medium plus toast – complex, strong vanilla and spice, grilled bread, "sweet" caramelized aromas smoke aromas*
>
> *Heavy toast – smoky and roasted aromas dominate, can be charry, coffee-like, penetrates 3-4mm*

*** What are the benefits of Toasted Heads???*

# Impact of Oak on the Wine

## Influence of oak barrel on wine composition

Oak wood is made of cellulose, hemicellulose, tannins and lignins. In raw wood, these compounds are not odorous. Toasting the wood causes significant changes in the wood's chemical composition. The heat breaks down the carbohydrate polymers (cellulose and hemicellulose) and the phenolic polymers (lignins and tannins) to create some new molecules. The toast level changes the amounts of these extractable compounds in the wood.

More than 200 volatile oak extractives have been identified. Some of the most important compounds are in the chart below. Toasting causes the degradation of lignin into vanillin. Thermal degradation of other phenolic molecules forms smoky and spicy smelling compounds like guaiacol and eugenol. Carbohydrate degradation makes toasty and caramelized smelling compounds like furfural and maltol. The oak lactones (which smell like coconut or sawdust) are present in the wood before toasting and then decrease as toasting time and temperature increases.

The tannins are non-volatile and they dissolve out of the wood into the wine as "oak tannin". The chart below shows some of the important French oak extractives, what they smell like and an indication of the way the concentration of these compounds changes with toasting.

| French oak extractive | Aroma descriptor | Amount present in: | | | |
|---|---|---|---|---|---|
| | | Untoasted wood | Light toast | Medium toast | Heavy toast |
| vanillin | vanilla | 0 | + | ++ | + |
| eugenol | clove | + | + | +++ | ++ |
| guaiacol | smoky | 0 | + | ++ | +++ |
| 4-ethylguaiacol | smoky spicy | 0 | + | ++ | +++ |
| maltol | burnt sugar caramel | 0 | + | +++ | ++ |
| furfural | toasty | 0 | + | ++ | +++ |
| E-2 nonenal | sawdust | +++ | ++ | + | 0 |
| methyl- octalactone | "oaky", whisky barrel, coconut | + | + | ++ | + |
| "green" tannins | Hard bitter tannin mouthfeel | ++++ | +++ | + | 0 |

# Oak Permeability and Wine Oxidation

## Wine penetration of stave wood

Wine pigments have been found to penetrate between 1mm and 6mm into the wood depending on the length of time, condition of storage and other factors. This represents the "waterlogged" zone. Progressing towards the outside, the next zone is swelled and about 18% water content but without free liquid. Then a zone of progressively lower moisture occurs where only water molecules diffuse until the outer surface of the wood is at equilibrium with air usually between 8% and 12% moisture in dry conditions.

Water and ethanol are both small molecules but ethanol is more volatile. Both diffuse into the wood as liquid and escape as vapor. The rate of loss is faster with higher temperature.

If the cellar is drier than 65% humidity, water is lost faster and the alcohol content of the wine slowly rises. More humid than 65% humidity and the alcohol content slowly falls. Non-volatile components concentrate in both circumstances and generally other volatile compounds do too since they are heavier / bigger than ethanol.

The evaporation through the sides of the barrel results in a loss of between 2% and 5% in volume a year. If the barrel is intact and the bung is tightly sealed, the diffusion of water and alcohol through the staves will produce a partial vacuum. Although there is some controversy about how the wine is slowly oxidized in the barrel, it is thought that atmospheric gases (nitrogen and oxygen) do not diffuse into the barrels and reach the wine, otherwise the vacuum would not form. In general, wine in barrel is exposed to oxygen during topping.

## Stave thickness

Stave thickness is important to barrel strength. Most barrels have a finished thickness of between 25 and 28mm. "Thin stave" designation from certain coopers usually means 22mm.

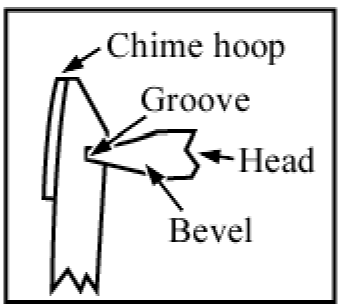
***How does the thinner stave barrel impact the wine as it is aging?*

The first millimeter of stave is penetrated in about 1 week after wine goes into a new barrel. Studies have shown that ultimately the wine only penetrates up to 6mm of the stave.

## TERMINOLOGY

**Barre**: the wood bar crossing both the heads of Bordeaux Chateau style barrels. These barres are ornamental in function rather than structural.
**Bilge**: The center of the barrel where it has its largest diameter
**Bung**: the tapered piece of wood, silicone or glass used to plug and seal the bunghole of a barrel.
**Chamfer**: the sloping ends of the staves
**Chime**: The end of the stave at the point of the barrel's smallest diameter. The part of the stave into which the groove and chamfer are cut.
**Croze**: The groove at the end of the stave or barrel cut to accommodate the head. The tool used to cut the groove is known by the same name.
**Dowels**: Small round wooden or metal pins or pegs used to join the heading pieces together.
**Flagging**: Dried rush or river reed used as a gasket material to fill gaps and voids.
**Hoops**: The strips of metal or wood which hold the barrel together. Galvanized steel is the most common material used, and the ends of each strip are riveted together.
**Hoop driver**: The tool used together with a hammer to force down the hoops to make the barrel tight.
**Shaving**: hand or mechanical removal of 1 to 3mm of the internal surface of the barrel to remove wine deposits and expose a fresh wood surface
**Spiles**: Small wooden conical shaped pegs used to seal holes and stop leaks

**Chime Detail**




| | Bordeaux Barrel | Burgundy Barrel |
|---|---|---|
| **Length** | 95 cm (3.11 ft) | 87.5 cm (2.87 ft) |
| **Circumference at the bilge** | 2.18 m (7.15 ft) | 2.28 m (7.48 ft) |
| **Volume** | 225 L (59.43 gallons) | 228 L (60.23 gallons) |

## REFERENCES

**Notes:**
UC Davis VEN 219 Natural Products of Wine class notes, online notes
http://waterhouse.ucdavis.edu/ven219/composition_of_oak.htm

Barrel notes on Zinfandel and Rhone Varietals, Jeff Cohn, Wine Business Monthly, May 2005
http://www.winebusiness.com/html/MonthlyArticle.cfm?dataId=38022

**Books:**
*Cooperage for Winemakers* by Geoffrey Schahinger and Bryce Rankine, Winetitles **2005**
*Chemistry of Wine Flavor,* A. Waterhouse and S. Ebeler, Washington DC, ACS **1998**
*Barrel Making, An Art in the Service of Wine*, Jacques Puisais, **2000** Editions Herme
*Chêne français pour vins du monde*, Soyez
*Sigma-Aldrich, Flavors and Fragrances Catalog 2003-2004*

**Acknowledgements to Cooperage Sales Reps and house promotional materials:**
Jim Stetson at Bouchard Cooperages, "Cooper Comparisons" an objective study with ETS Labs, 2002
Demptos press kit
Bayard Fox at Saury
Mel Knox Barrel Broker
Bill Luebke at *The Good Scents Company*