Beyond « clear wood » : exploring the structure-properties of figured woods and of woods with strong gradients selected in craftsmanship

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Introduction :

This poster presents a beginning Ph.D. research. The subject focuses on an apparent paradox between different approaches to wood: from the viewpoint of engineering sciences (as from industrial uses), "good" wood is orthotropic, well oriented and homogeneous, singularities are considered as "defects". In standing tree, as the living organism, homogeneity can be considered as a singularity. And from the viewpoint of artisanal usage, either heterogeneity or singularities or both can be considered as "defects", on the contrary, as "qualities" according to the considered uses. The subject, therefore, concerns the permeability between the concepts of "defect" and "quality". It aims to fulfil the gaps in knowledge of heterogeneous woods (figured woods, grain deviations, pieces including gradients, etc.). It also concerns usage-function adequacy and should open the way to a better identification of "precious" wood (e.g., figured) and to a better valorisation of wood types that are usually underestimated.

The scientific question is posed, different from most current research work on "clear wood", for seldom addressed in wood mechanics: How to explain the mechanical behaviour of wood with strong gradients in its properties or with grain deviations or both? Knowing that such types of wood are sought after and deliberately selected in several fields of woodcrafts. The "figured wood" is a particular concern here, because of the trade-offs between mechanical and aesthetical criteria for the choices. The main orientation of the cells does not follow the axis of the trunk, but instead the cells' direction present more or less periodic reorientations, according to different schemes and material axes (Beal and Davis, 1977).

Previous research at LMGC

Initial work on the structure-property relations of certain cases of figured wood has been initiated in the LMGC wood team over the past dozen years: consideration of a case of interlocked grain (Brémaud *et al.*, 2010), then, for the diversity and possible biomechanical causes of this figure (Cabrolier, 2006; Cabrolier *et al.*, 2009; collaboration EcoFoG Guyana). Another work concerned the analysis of reduced anisotropy in the burr of "Thuya" (El Mouridi *et al.*, 2011). More recently, this theme has been integrated into the "ethno-bio-mechanical" approach developed at LMGC (Brémaud, 2016), in which the study of mechanical behaviour is considered as an interface between the botanical origins of the variability/diversity of the material, and the cultural implications of the human-wood relationship in crafts (Cabrolier and Brémaud, 2014). In this new perspective, two studies

were discussed, taking into account compromises between mechanical and aesthetic criteria: deliberate selection of reaction wood sectors (Cabrolier *et al.*, 2015), and wavy figure in lutherie maple (Alkadri *et al.*, 2018). The topic of gradients along the radius was also addressed for spruce resonance wood (Carlier, 2016).

Work plan of the beginning Ph.D.

The scientific project is structured according to the 5 tasks below, with the core of the Ph.D. subject corresponding to tasks b), c), d) (while tasks a) and e) will be included in larger frames of research):

a) Surveys with craftsmen and possibly with foresters/sawyers to identify the uses of wood with high gradients of properties and the selection trade-offs between mechanical, aesthetic and resource constraints.

b) Establishment of a typology of the types of wood concerned (figured wood, grain deviations, pieces naturally curved and/or including different sectors and/or types of wood...) according to different usages.

c) Exploration of botanical diversity (interspecific) and variability (intraspecific) to contribute to the question of the determinism of certain singularities and their mechanical characteristics.

d) Reduction of the problem according to a typology of the observation scales relevant for the multi-scale analysis of the relation between structure (sub-parietal scale, cell orientation, anatomy/tissue organisation, atypical gradients on the radius and/or section of a tree, etc.) and mechanical properties (including dynamic/vibrational and anisotropy). Then, experimental characterization (and modelling) of the structural mechanical repercussions in conditions of use of these woods with high gradients of properties, following a reduced selection of modalities representative of the established typology.

e) Study of the visio-tactile sensory perception by craftsmen, especially for "figured" woods (wavy, flamed, birdseye, interlocked grain, etc.)

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