Archaeometrical contributions in the Japanese architecture in France

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ARCHAEOMETRICAL CONTRIBUTIONS IN THE JAPANESE ARCHITECTURE IN FRANCE: THE PAVILIONS OF ALBERT KAHN'S GARDENS (BOULOGNE-BILLANCOURT, FRANCE)

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ABSTRACT:

This study takes place within the framework of an ambitious restoration project of the two Japanese lodges situated at Boulogne-Billancourt, in France. The philanthropist banker Albert Kahn builds a set of gardens during the 19th century with a Japanese "village". Manhandled by the time, restorations were decided with, in parallel, an exhaustive archaeological investigation of these buildings. The AKAHN project: "Albert Kahn: archaeology of a Japanese Heritage" began in 2015. Exploratory analysis were made to direct a part of the work and in particular to find the original colors. The measurements were realized according to non-destructive methods and techniques mainly *in situ*. The present results are not complete and are in the continuation especially for the wood. They concern the dendrometrical studies on both houses and the characterization of their polychromies. They also participate in the implementation of a database on Asian woods in France: in the 19th century in Europe, during the period named "Japanism", numerous buildings seem to contain same kind of woods.

KEYWORDS: *Archaeometry, Wood, Polychromy, Japanese architecture, France*

1 INTRODUCTION

Albert Kahn's gardens are located in the Hauts-de-Seine, near Paris, in France. There have several buildings including two Japanese lodges brought back from Japan by Albert Kahn around 1900 (Figure 1). [1-3]
As part of AKAHN's project, they were restored in 2015 and 2016 using a traditional Japanese method: complete dismantling and reassembling. The aim of this project is to understand this heritage (origin, construction in Japan and in France, etc.) through a multidisciplinary approach combining archaeology, archaeometry, architecture, history, 3D representations, etc. [4-6]

The present study was conducted as part of the scientific part of the project. We decided to study the wood, main component of the buildings, but also painted plasters, unknown.

Figure 1: *Left: West lodge; Right: East lodge*

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The aims of our studies are as follows:

- To obtain the necessary information for the restoration,
- An initial and as accurate as possible of its state before restoration,
- To advance research on these houses,
- To improve our knowledge of Japanese architecture in France and Europe,
- To exchange collected data with Japanese researchers to supply dendrometrical databases.

2 METHODOLOGY

The study was conducted in two parts: the first one *in situ* and with non-destructive methods before restoration and then the second one on samplings and laboratory analysis when restoration.

2.1 WOODS

The wood study was led in two phases: first, on some wood available before restoration and then on a selection of wood chosen during the restoration. All data were taken *in situ* and treatment was done in a laboratory.
We decided to carry out two types of studies in parallel: on the first hand, dendrometrical measurements that will give us an absolute and relative approach to the date, possibly a biogeographical origin and a morphological analysis of the wood. On the other hand, a xylological study on some of the wood studies by dendrometry was to determine and to analyse the wood species.

2.1.1 Dendrometry

In the case of Albert Kahn gardens' two pavilions, we used a non-invasive methodology adapted to wooden art works. After a manual light dusting of the surface, we realized, at first, a maximum of *in situ* data taking on non-dismantled buildings and carried out measurements on macrophotographs (Figure 2). They are done on longitudinal surface because the wood is perfectly split on radial way and they are coniferous species.

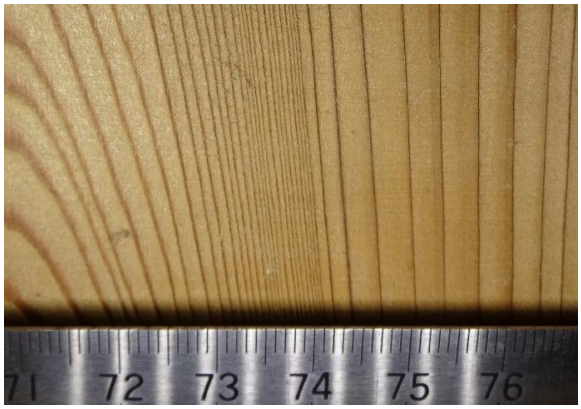

Figure 2: *Detail of board 2, gate 1, East lodge.*

The measurement of rings width was performed on each image using software (Mensor[1]). The pictures were taken according to a strict protocol of stability, lighting and scale (Figure 3). [7]

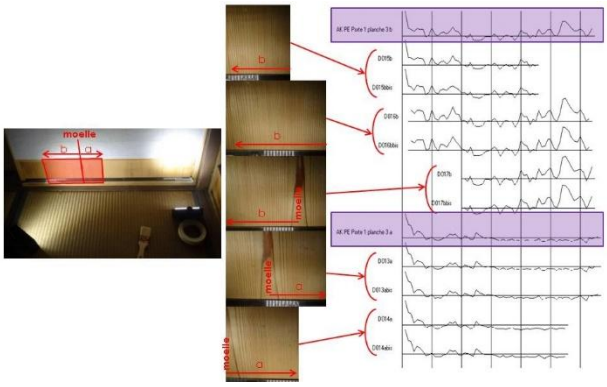

Figure 3: *Example of macrophotographs made on a plank of a* shōji *(on left) and measurements of tree-ring widths (on right) in the two directions: this wood was split near the pith.*

During the preliminary study, tree-rings measurements were performed on visible transverse faces of 4 outdoor round beams (two in each house), 8 tie beams of West lodge (East house have none) and on lower parts of 25 *shōji*[2] (12 in the East lodge and 13 in the West house) for a total of 87 boards with 81 measured (Figure 4).

Figure 4: *Example of measured timbers (in red). Left: the lower parts of* shōji*; Top right: tie beams; Bottom right: an outdoor round beam.*

During the restoration, the houses were totally dismantled and the woods were left to us for a short time (Figure 5) to take information. We then had to take a maximum data during this very short period of time. Only part of these timbers was analysed in the laboratory. Indeed, the photographs, around 1400, and the study of left wood not re-used would require nearly two years of work to a specialist only for their post-treatment. So we selected a number of woods meeting certain criteria in order to be as representative as possible for this first part of work:

- Containing a large number of rings or with particular growth,
- Coming from the structure but also walls or decorations,

[1] S. Meignier et D. Pousset, 2002, software

[2] Japanese door made of translucent rice paper mounted on a wooden structure.

- Coming from a maximum of rooms (*genkan*, kitchen, etc.),
- 3 hardwoods et 44 softwoods
- 25 from East house and 22 from West house
- Posts, beams, planks, lintels, etc.

It represents some 47 timbers studied to add to the corpus of the preliminary study.
The most representative results were sent to Mr. Takumi Mitsutani so that he could do a comparison with his dendrochronological database on Japanese wood. This data is being processed.

Figure 5: *Part of the* corpus *of wood to be analysed.*

2.1.2 Xylology

The xylology determines the wood species. This requires making very fine cuts on the three faces of the wood: transverse, tangential and radial (Figure 6) and comparing with existing database. Mrs. Mechtild Mertz, Japanese wood specialist and Mrs. Victoria Asensi Amoros, from Xylodata, assist us in determining the species used.

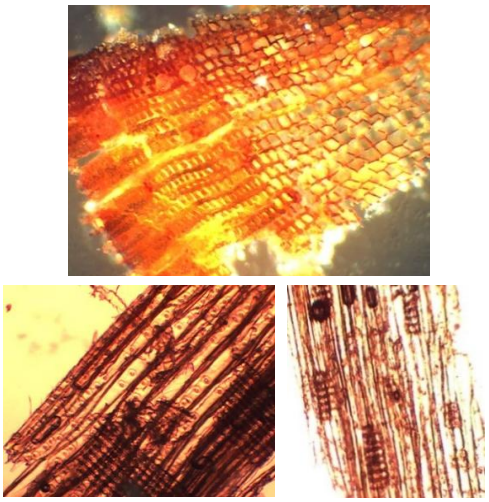

Figure 1: *Sample D1: transverse, radial and tangential faces.*

2.2 POLYCHROMIES

The walls have large different coloured layers depending on the rooms and houses as an orange, a very dark grey, a beige, etc.

To better characterize these paintings, we decided at first to perform XRF analysis *in situ* (Figure 7) to try to identify the chemical elements present. Colorimetric measurements were also performed. These methods were chosen because they are non-destructive, portable, fast and commonly used.

Figure 7: *Preparation of the fluorescence X machine for* in situ *measurements. (Photo : C. Lavier)*

During the restoration of the two houses, we took samples from these painted plasters to study the paintings in the laboratory (Figure 8). We decided to sample all the colours: sixteen samples from seven different colours were so studied. We then performed stratigraphical sections of these plasters and we observed them by optical microscopy. Considering the results, we decided to analyse some samples by SEM-EDS (scanning electron microscope coupled to energy-dispersive X-ray spectroscopy) to chemically characterize the interest for the restoration of the paintings.

Figure 8: *Examples of samples taken for this study during dismantling*

2.2.1 X-ray fluorescence (XRF)

XRF gives us information on the chemical composition of the paints. It determines the presence of chemical elements from the aluminum and the position of the lines on the obtained spectrum indicates the nature of the present elements.

2.2.2 Colorimetry

The colorimetrical measurements allow the restoration manager to identify the colours to be used. It also helps us to position the colour in the selected referential, in this case the L*a*b* system. We also measured the dominant wavelengths for each colour.

2.2.3 Optical microscopy

To be studied, the samples had to undergo a preliminary preparation: resize, set in resin and cutting or polishing to obtain a flat surface. We then obtained a stratigraphical section of the sample.

2.2.4 SEM-EDS (Scanning Electron Microscope)

Analyses by SEM-EDS (Figure 9) permitted us to identify the chemical elements present in each layer of paint in each stratigraphical section. We chose to analyse the samples according to the results obtained by other methods, namely: the original paint composition to identify the pigment.

Figure 9: *Analysis of samples by SEM-EDS in progress.*

3 RESULTS

3.1 WOODS

3.1.1 Dendrometry

From the measurements of woods, 15 dendro-means were realized, up to 31 samples or covering over a period of 192 years: one with hardwood and the rest with softwood. The dendromorphological studies helped us to determine that some samples come from nearby trees and have similar growth characteristics (characteristic years; Figure 10). This permits us to establish that they were from the same kind of trees, the same forest and the same age.

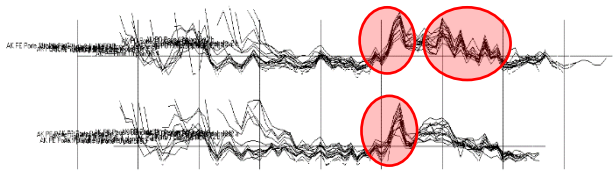

Figure 10: *Mean19: the two parts whose series have a specific and similar positive amplitude (in red).*

Some averages contain wood from East and West houses proving that the timbers of these two buildings are from same areas and same periods. Both houses were probably built at the same time and with the same wood (Figure 11). At the moment, they did not allow us to establish the date of the construction of these houses. We need more samples. It will be done during restoration by data samplings and after restoration with non re-used woods

Figure 11: *Mean "AK 2016 Moy 2" (in purple) incorporating elements from West house (in green) and East house (in blue).*

3.1.2 Xylology

As the restoration work was only completed in June 2016, the majority of the wood is still being sampled. So far, we checked that some *Hinoki* cypress (*Chamaecyparis obtusa*), Japanese cedar *Sugi* (*Cryptomeria japonica*), Sawara cypress (*Chamaecyparis pisifera*), Himalayan cypress (*Cupressus torulosa*) and Larch (*Larix sp.*) were part of some of the timber used.

3.2 POLYCHROMIES

3.2.1 X-ray fluorescence (XRF)

The XRF analysis gave us to detect lead in some paints. However, the different layers of paint are not uniform (we obtain large variations in results for the same paint: Figure 12), it is difficult to know exactly which layer it comes from. Therefore, it is not possible to calculate quantitative compositions (amount of each chemical element) and even qualitative ones (present elements) of each layer. At this stage we can only have a global vision of these paintings and elements present in large quantities (major elements) such as calcium or zinc.

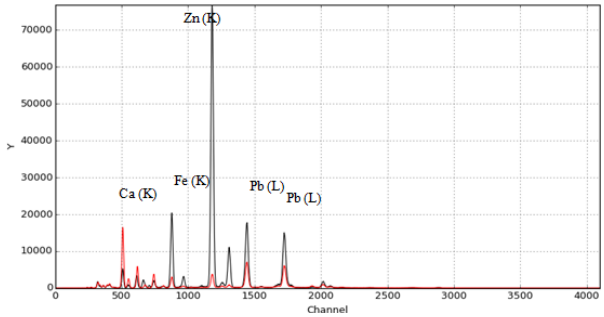

Figure 12: *2 orange paint spectra: the same elements are present, but their concentrations vary widely.*

3.2.2 Colorimetry

We were able to realize many colorimetrical measurements on different layers which gave us a better insight of the colors from the successive restorations (Figure 13). However, these data cannot be directly used during the restoration as it is not possible to properly

analyse the oldest blue layer and consequently to have accurate information.
However, these measurements allow us to keep track of paints used throughout the 20th century on these lodges and which were destroyed during restoration.

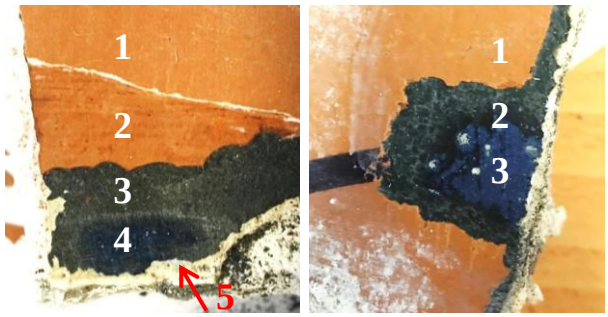

Figure 2: *Left: we have scoured only 5 of the 10 layers; Right: only 3 from 8 present layers.*

3.2.3 Optical microscopy

Observations by optical microscopy have allowed us to identify the blue paint (Figure 14) as the original one: it is present on a majority of restored painted plaster. However, these are non-existent in texts and archives and could have remained unknown if we did not continue our work on painted plasters.

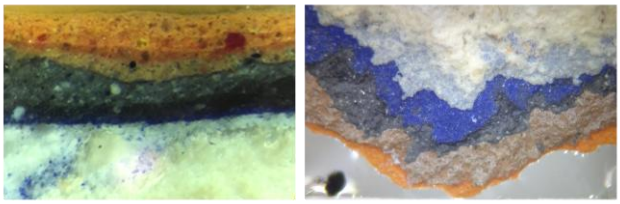

Figure 14: *Left: cut; Right: view from below. Blue pigments are highly visible, which helps target the SEM-EDS analysis.*

3.2.4 SEM-EDS (Scanning Electron Microscope)

Thanks to the analysis performed by SEM-EDS (Figure 15), the blue pigment was identified as synthetic ultramarine blue (or sodium aluminosilicate). It was used for restoration. We also found that the mix used in the original paint (to increase the coverage of the paint) was kaolinite (potassium aluminosilicate). The other paintings showed little interest for the restoration.

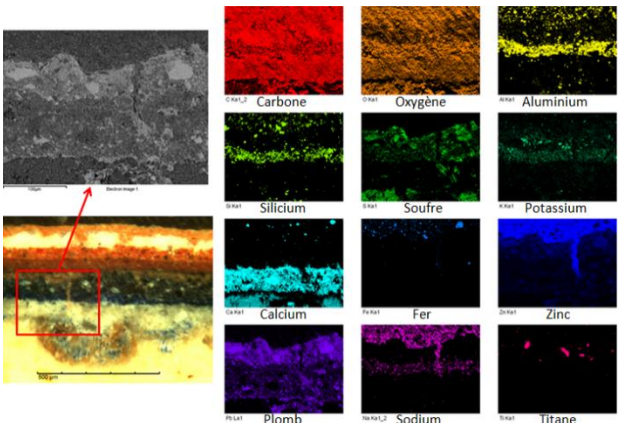

Figure 15: *Map of an area of the sample AK14-2. The chemical elements are represented by different colors.*

4 CONCLUSIONS

The various analyses, carried out during the exploratory study, permitted us to focus our research in order to get a wider knowledge during the study for the restoration. Indeed, without the first study, we would not have been aware of the various restorations on painted plasters and we would not have found the original blue. This also allowed us to make some assumptions about the woods that it was necessary to confirm or reformulate.

Many archaeometrical techniques were used and have already provided important information about the history of these two lodges, the information was used for restoration.

WOODS: we already know that we are in the presence of multiple species. At the moment, the expected datings and provenance were not obtained because this part of project was ended in last June and that not reused timber just arrived in the laboratory. We can still say that some timbers of the two houses come from same areas which also confirm their contemporary building and that there were lots of timber prepared for both buildings and not separate lots by house. The xylological analysis helped us to identify species not expected for this kind of buildings: larch (*Larix sp.*) and Himalayan cypress (*Cupressus torulosa*) already indicating that supply circuits are larger than expected.

POLYCHROMIES: numerous samples and systematical observation by optical microscope enabled us to define the presence of blue on the deepest layer of several coats of paint: the original blue found on autochromes. Thanks to SEM-EDS analysis, it was identified as ultramarine blue (sodium aluminosilicate) mixed with kaolinite (potassium aluminosilicate). This information was used for the restoration (Figure 16). Colorimetrical analysis coupled by optical microscope revealed a large number of restorations carried out in the 20th century, showing unknown interventions in the history of these pavilions. The knowledge then obtained is part of a memory work. Indeed, plasters were destroyed during buildings' dismantling and no longer exist.

Figure 16: *Left: East lodge being restored; Right: Blue paint test on plasterboard present on site.*

The further dendrometrical analysis, combined with information from the carpenters-restorers will enable us to lead to new discoveries about the species, their provenance, their datations, etc. We know that it needs

several years but it should allow us to answer the outstanding questions: what are all the species of wood used? What wood for what use? Where do the timbers come from? What are the wood timbers supply circuits? Were they known, new or adapted at the request of Albert Kahn? Was the wood treated *in situ* and worked which is typical of Japanese masters and/or combinations of European techniques? What were the various restorations undocumented in the archives? When? What it can teach us about Japanese architecture in France and Europe as well as exchange of architecture from Japan to France?

Interdisciplinary program, the AKAHN project allowed us to demonstrate the interests of archeometry associated with archeology, history and architecture for analysing buildings imported from Japan. We hope that this type of project will become widespread and that these actions will be applied to other structures of heritage interest or even to those considered as works of art.
Pioneers for these types of multidisciplinary studies, this program has already provided many results. It is necessary to continue archaeometrical studies of these pavilions but also other Japanese buildings in France or Europe. These studies involving many international experts, it would be great to extend these relations but also to develop the study of architectural Japanism in Europe as well as international dendrometrical databases.

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