Buildings and wood trade in Aix-en-Provence (South of France) during modern period

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Title

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Abstract

Many buildings are being restored in the city of Aix-en-Provence, southeastern France and allowed systematic dendrochronological analyses. 144 fir timbers (*Abies alba* Mill.) were examined and dated between 1303 and 1933. They highlight three felling phases (Medieval period, 17th-18th century, and 19th century). The best documented one corresponds to the 17th-18th centuries and coincides with significant building activity connected to the status of Aix, which is the parliamentary capital of Provence. Around Aix-en-Provence, it is difficult to find timbers with good dimensions. Our results show that timbers were transported from the Alps to Aix's buildings. Potential testimonies of this timber trade have been found, such as raft assemblage marks, and carved signs and letters. A dendroprovenancing case study shows that between 1810 and 1890, some of Aix's timbers could have come from the Northern French Alps or the Verdon-Durance region. Finally, the lack of timbers with good dimension and the difficulties of timber supply contributed to the development of reuse economy and technical innovation. These results are the foundation of a future well-established dendroprovenancing approach in the Southern Alps.

Keywords

Wood building, *Abies alba* Mill., dendroprovenancing, frameworks, trademarks, Aix-en-Provence, Alps

1. Introduction

Aix-en-Provence's history dates back to Antiquity (it was the first Roman foundation in Gaul, dating back to AD 122; Guyon et al., 1998), but the city centre architecture was inherited from its status as parliamentarian capital of Provence since 1502. This status attracted a parliamentary aristocracy, new religious orders, fiaries and many artists. Under their action, from the 16th century but especially from the 17th and 18th century, many buildings were constructed and decorated in the city (Boyer, 1972; Gloton, 1979). Parliamentarians ordered the construction of private mansions in the city, residences in the countryside, and financed friaries or chapels in churches (churches of mendicant convents) (Claude and Rossetti o Roscetti 2015; Claude et al., in press; Claude, 2010). Gloton (1979) and Boyer (1972) studied these buildings and their decors. Their works are seminal, nevertheless, their art history approaches did not take into account the supply and provision of material or its implementation.

Although most of these buldings are protected historical monuments for a long time, despite these legal protections, restoration works, renovation or enhancement did not take old framework into account. Since 2007, the development of building archaeology expertise in the archaeological city department (Direction Archéologie et Muséum d'Aix-en-Provence) led to systematic dendrochronological studies. The first of them was in 2013-2014, during the significant restoration works in the former Prêcheurs church (current Madeleine church).

All these monographic studies gradually contribute to framework knowledge in Provence, a region where framework and timber studies are infrequent and relatively new. Bernardi (1995) made a first overview in his thesis on Aix's construction industry between 1400 and 1550, using textual documents. Recently, Bouticourt (2016) completed a thesis on Mediterranean frameworks and published several papers on this subject (see Bouticourt and Guibal, 2008). Bernardi and Bouticourt were interested in timber supply regions, transport methods, timber trade and construction, in southeastern France.

Aix-en-Provence is located in Provence, between the Alps, the Mediterranean Sea and the Rhône corridor. The region is in the Sounthern rim of the temperate zone and the various topographies produce many local climatic shades due to altitude, distance to the sea, exposure, narrow sides and slope value (Climat et changement climatique en région Provence-Alpes-Côte d'Azur, 2016). The mountain climate in the northern part of the area is dry and very sunny. It enables the growth of Scots pine (*Pinus sylvestris* L.), European larch (*Larix decidua* L.), fir (*Abies alba* Mill.), stone pine (*Pinus cembra* L.) and oak (*Quercus* spp.). Further south, European beech (*Fagus sylvatica* L.), holm oak (*Quercus ilex* L.) and juniper (*Juniperus* spp.) are emerging in Provence, along with, typical Mediterranean trees like Aleppo pine (*Pinus halepensis* Mill.) and olive trees (*Olea europea* L.) (Blanchard, 1956). Therefore, the lower Provence region does not have large forests for timber production, and Aix-en-Provence had to import this material.
Preliminary observations and analyses confirmed this fact, which allows us to make a start on wood trade during the Modern period in Aix-en-Provence and on the solutions provided to thwart the difficulties of timber supply.
This study was possible because of (i) a large amount of well-preserved timber, (ii) the presence of archaeological documentation for some sites, (iii) founding studies on archives and frameworks (Boyer, 1972; Gloton, 1979; Bernardi, 1995; Bouticourt and Guibal, 2008; Bernardi 2007a) and finally, (iv) the construction of dendrochronological chronologies in the French Alps over the past two decades (Serre, 1978;Serre-Bachet, 1986; Tessier, 1986; Tessier et al., 1990; Belingard, 1996; Belingard and Tessier, 1997; Edouard, 2010; Saulnier, 2012; Shindo, 2016).

2. Material and methods

Timbers from seven buildings were sampled for dendrological and dendrochronological studies (**Fig. 1**): two private mansions (Caumont and Maynier d'Oppède), three castles

(Grand-St-Jean, Jas de Bouffan and the Seuil in Puyricard) and two churches (Madeleine and St-Jean-de-Malte). Only three of these dendrochronological studies were commissioned as part of building analyses: the Madeleine church, St-Jean-de-Malte bell tower and the Maynier d'Oppède attics.

2.1 Field sampling and data collection

The initial step was to carefully observe the timbers, and note tool marks and carved marks that were photographed and measured. We took samples from 245 timbers, with a chain saw, electric Rinntech borer and Pressler borer. When sampling was not possible, we took pictures of the tree rings.

2.2 Dendrochronological analysis

Most of the sampled timbers used for tree-ring analyses came from fir, although timber from Scots pine and European larch was also used, but to a lesser extent. For this study, only the fir samples were considered.

To improve the visibility of individual tree rings, we smoothed the surface with a sanding machine and/or a razor blade.

Ring widths were first measured with 0.01 mm precision using a digital LINTAB positioning table connected to a stereomicroscope and TSAP-Win Scientific software (Rinntech, 2014). In a second phase, tree-ring series were crossdated using the DENDRON-IV software (Lambert, 2011). The dendrochronological series were indexed, using the Corridor standardisation (Lambert, 2006, 2010).

2.3. Dendroprovenancing

Dendroprovenancing is a dendrochronological application that determines timber origin by comparing tree-ring series (Eckstein et al., 1986; Wazny, 1992; Haneca et al., 2005; Bridge, 2012). Moreover, interdisciplinary studies including dendroprovenancing, historiography and archaeology, provide information on wood supply, trade, route and wood intensity.

To compare archaeological wood with chronologies from living trees, it is common to use Student's *t*-value. The higher the *t*, the better the correlation, which allows to infer a source forest (Wazny, 2002; Bridge, 2012).

In southern France, the difficulty is that living fir chronologies date back in average to the 18th-19th century, whereas archaeological woods are older, which hampers any comparisons. A solution would be to build a living trees model and to compare some parameters (such as average tree-ring width and average sensitivity; Eiβing and Dittmar, 2011) between archaeological timbers and living trees. Unfortunately, this model does not exist yet for the studied aera, so we used a correlation matrix instead.

In a correlation matrix, the relation between each chronology can be presented in a symmetrical square chart, "*that compares and shows correlations obtained from all of the different possible pairs*" (Lambert, 2011, 26). The argument is the probability (between 0 and 1) associated with the *t*-value. The darker the box, the better the correlation. Here, for a dendroprovenancing case study, we chose the 1810-1890 window because it is the oldest period with enough chronologies: 10 living trees chronologies and one archaeological chronology (from the Grand St-Jean castle in the Aix countryside) (**Fig. 2**).

3. Results and discussion

3.1. Dendrochronological dating

A total of, 144 fir timbers were crossdated with the southern French Alps master chronologies (presented in Shindo et al., 2017), between 1303 and 1933 (**Table 1**). Three main construction phases were identified (**Fig. 3**): the end of Medieval times, 17th-18th century and the 19th century. The last rings measured on the 144 timbers were dated between 1402 and 1933. Felling of trees seem to be almost continuous from the 15th to the 20th century but a closer look at these dating results is needed.

Bernardi (1995) studied Aix building activity between 1400 and 1550 and found several texts referring to the purchase of timber and building contracts. Fir, larch, pine, walnut and oak are the main types of wood mentioned in these texts. This is coherent with our dendrochronological dates attesting for tree fellings during that period, although the corpus of Medieval timber should be strengthened.

As for today, no fellings have been observed between the last third of the 16th century and the first third of the 17th century in dendrochronology, independently of the tree species. However, the fact is, building was intensive during that time (Gloton, 1979; Boyer, 1972). Therefore, our results do not accurately represent building activity. There are three ways to explain this: (i) non-representative sampling, (ii) re-use of older timbers and (iii) destruction of timbers.

Many fellings happened during the 17th and the 18th century, making this the best-documented period dendrochronologically. This long building phase, well-documented by several texts (Gloton, 1979; Boyer, 1972), stopped during the revolutionary period, at the end of the 18th century. This dendrochronological data decrease could be explained by a bias in our data, or by a slow-down in demographic growth for the city of Aix from the French Revolution (1789) to the mid-20th century (Van Leeuwen, 1995). At the end of the 18th century, the new French government seized and sold many religious and noble properties. According to Van Leeuwen (1995), some of these buildings were totally destroyed by the new owners to recuperate different materials, while other buildings were restructured to create several smaller homes inside.

Finally, samples representative of the 19th and the 20th century are scarce because we focussed on earlier buildings.

It is necessary to keep in mind that for the moment, these preliminary results are not yet entirely representative of Aix's ancient construction activity, but they suggest the existence of construction gaps in the late 16th and the early 19th centuries that should be studied in the future.

3.2. Marks on the beams

The vegetation around Aix-en-Provence, is of Mediterranean type, which makes it it difficult to find trees with long and straight trunks. That is why, for a long time, people imported timbers from the mountains where timber needed for construction purpose could be found.

Timbers were transported from the mountains to the plains by roads and by water, a faster and cheaper way, evidenced on the Durance river from 1094 (Bernardi, 2007b). The earliest quote of wood rafts on the Durance and Rhône rivers, dates back to 1094 (Barruol et al., 2005). In Aix buildings, we found assemblage marks and carved signs and letters that are potential testimonies of this timber trade.

3.2.1. Assemblage marks

In two places, a former post house and hors exchange[1] and a block of flats[2] (most certainly a former private mansion), we observed joists with holes and dowels. These joists were not sampled and remain undated. Holes are triangular (with the point turned towards the pith). They are isolated or combined two by two (**Fig. 4a**). One joist (rectangular section) still has dowels (**Fig. 4b, c**): four dowels arranged in a square on one side, two dowels on the opposite side. Two dowels and a wedge in relation to one of the three dowels were sampled and identified as European beech. These holes and dowels enable to gather and hold timbers in rafts. These two examples from Aix perfectly illustrate the data established in the lower Rhône valley, where dowels are mostly made of beech, sometimes maple (*Acer* spp.) and chestnut (*Castanea sativa* Mill.), and are often arranged in a square (Bouticourt, 2016). In Germany, Eissing and Ditmar (2011) and Eiβing (2016) identified rafting relics (holes and "wooden nails" (dowels) on beams near Rhine, Danube, Main and Elbe rivers, and in the south of Spain, Dominguez-Delmás et al. (2018) observed wooden pegs of oak (*Quercus* subg. *Quercus*) in roof structures of a major church, which had been used to assemble rafts of pine timers in the Guadalquivir river. Therefore, similar solutions were employed to build rafts and to transport timbers in different regions.

3.2.2. Geometrical signs and letters

In three buildings (the Caumont private mansion, the Madeleine church and the Grand-St-Jean castle), we found geometrical signs arranged side by side along the beam length and connected by a horizontal line. These signs are cruces, vertical lines, diamonds, half diamonds ("V") and U-shaped and measured around 20 cm in length and 8 cm in height.

We put all the other geometrical signs together because they were not connected by a horizontal line. The classification will be improved once more examples are acquired. The oldest geometrical sign (on a joist from 1409) was carved with a gouge, a tool with a half-moon blade. The ones dated from 1489 to 1716 were carved with a chisel, a rectangular section blade (**Fig. 5**).

Thomas Lutz and Ulrike Schurrer, amongst others (Eiβing, 2009; Eiβing, 2016), listed and analysed geometric marks similar to the carved signs observed here in Germany. These marks identified timber owners and wood trade players so they needed to be clearly visible. That could explain their big dimensions. During the process of squaring the timbers and placing them in the buildings, many of these marks disappeared or are not visible anymore.

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[1] Restaurant La Brocherie, 5, rue Fernand Dol.

[2] 35, rue Mignet

Alphabetic marks could be merchant marks as shown by Baume (2011). She found one mark mentioned in a judicial document from 1607, a commercial transaction between trees owners and a wood trader from Aix, “captain Pascal”: “*la marque dudict capitaine Pascal qu’est un E”*[3] (in French), wich means “the mark of captain Pascal which is an E”. The “E” letter is drawn on the document but until now, we did not find any timbers with a “E” mark.
Letters are clearly identified on three beams. A tie-beam from 1652 has an “AP” (about 20x20 cm), a joist from 1697 has an “IA” (or maybe “TA”, about 13x20 cm) and another undated tie-beam has an “AT” (about 10x20 cm). All of them were carved with a chisel and there is a capital “A” letter every time. It is possible that this letter is a reference to the destination of the wood, the city of Aix. Finally, a purlin (a beam supporting the roof rafter) from 1750 has a different type of letter, a small “c” (3x4 cm) burned into the wood, probably with a hot stamp.

To our knowledge, there is not any published study on the identification of forest owners, woodcutters, traders and carpenters marks in southeastern France. Such studies would be essential to understand commercial exchanges between the moutains and the plains and would require a collaboration between professionals, and the implementation of a multidisciplinary database.

3.3. Dendroprovenancing: Grand-St-Jean castle, between 1810-1890

During the 1810-1890 window, the Grand St-Jean castle chronology synchronized with three of the 10 living trees chronologies from the southern Alps (**Fig. 6**). That means it is possible that the castle timbers came from these geographical areas (**Fig. 7**).
Between 1400 and 1550, Bernardi (1995) identified, five supply areas for Aix-en-Provence city in textual archives: four south-alpine valleys (Grand-Buëch, High-Durance, Ubaye and Bléone) and the Aix region (see **Fig. 7**). Our case study results suggest two supply areas for the Grand-St-Jean castle (**Fig. 6**): northern Alps (“TERM” for the Termignon site in Maurienne) and Verdon – Durance (“BVZ” and “STP”, the city of Thorame in Mercantour) (**Fig. 7**). Because of the reliefs, woods from the northern Alps travelled by the Rhône river to Avignon city and then by road to Aix. Woods from Verdon joined the Durance river at the confluence between these two waterways.
Our results are differents from Bernardi’s (1995) five supply areas. Because wood supply areas change over time, they were probably more plentiful in farther regions during the 19th century, than during the 15th and 16th century. Moreover, where wood transport over long distances was previously difficult, it was easier at that time (Eissing, 2011).
This short case study only took into account one building that cannot be representative of Aix’s building activity. It highlights the necessity of interdisciplinary research. It is essential to study supply forests to build chronologies and tree models; to go through Modern historical documents as Bernardi (1995) did, in order to trace commercial trade routes, and finally; to analyse more structural timbers, the tangible evidence of this trade between the mountains and the plains.

[3] Regional archives from Alpes-de-Haute-Provence, Estrayer Barthélemy, 2E4758, f°132(v°)).

3.4. Reuse economy and technical innovations

When the city of Aix city and its countryside were under construction, the lack of timbers with large dimensions must have contributed to the development of reuse economy and technical innovation.

3.4.1. Reuse economy

It was a weighty and costly activity to bring timbers from the mountains to the cities in the plains, and, there was also over-exploitation, by the royal navy amongst others (see Pichard, 1999): it was more and more complicated to find timbers with large dimensions, which made it necessary to reuse material. Bernardi (1995) talks about a “true traffic of second-hand materials” and we found unused assemblage marks (generally mortises), which evidence the re use of timber from a former installation now inexistent.

In a private mansion (Maynier d’Oppède), two trusses from the roof had signs of having been repaired (**Fig. 8**). The damaged part was removed and a new timber was put with the old one, with a “jupiter assemblage”. One of the old parts is dated from 1758 (the other one is undated), and the two new parts are dated from 1847-1848. They could correspond to the rearrangement of this mansion into a university building in 1846: it was easier (or more economic) to repair the beam-ends than to change them.

5.4.2. Reinforced beams

The reinforced beams appeared in Italy during the first part of the 15th century (Bouticourt and Guibal, 2008). It is a wood assemblage, generally made of two short beams on top, and one long beam below, to obtain one long thick beam with better resistance to stress flexion. It helps to spare wood and/or to provide a wider section than natural unassembled wood.

The only known example of a reinforced beam in Aix is in the Prêcheurs church: there are three reinforced beams (tie beams) in the nave framework, built between the end of the 17th century and the beginning of the 18th century (**Fig. 9**). They are 12 m long, and three of the six short beams above are dated from the beginning of the 15th century. The three other short beams and the three long beams are undated.

The precise coupling between the beams and their consistent dates, suggests the entire reuse of the reinforced beams rather than a rearrangement from several smaller beams. Future dating of the last parts of these reinforced beams will confirm or refute this hypothesis. This would provide a new example of interactions and exchanges between Italy and Provence during the 15th century. Whatever the reason, the reinforced beams from the Prêcheurs church perfectly illustrate how common reuse practices were at the time. Here, these tie beams could originate from the Medieval nave framework which had the exact same width as the 17th century framework.

4. Conclusion

The dendrochronological analysis of this hitherto unstudied timber material from the city of Aix-en-Provence and its countryside, provide new information on building activities and human practices over a seven - century period.

The new archaeological *Abies* chronology for southeastern France, which includes 144 cross-dated dendrochronological series, spans from 1303 to 1933. Dating allowed to identify three felling phases using this wood species. The longest one is the Modern period (17th–18th century), when building activity was significant, especially under the influence of Parlementarians.

The first marks identified on the beams, the literature based on archival research, and dendrochronology, are the basis for a future well-established dendroprovenancing approach. This interdisciplinary research combining dendrochronology, history and archaeology, enhances our knowledge of historic buildings, wood trade and mountain and plain exchanges in the South of France during the end of the Medieval period and the Modern period. The present data will contribute to future comparative studies at European level.

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Figures

Figure 1
a- St-Jean-de-Malte church, b- Maynier d'Oppède mansion, c- Jas de Bouffan castle.

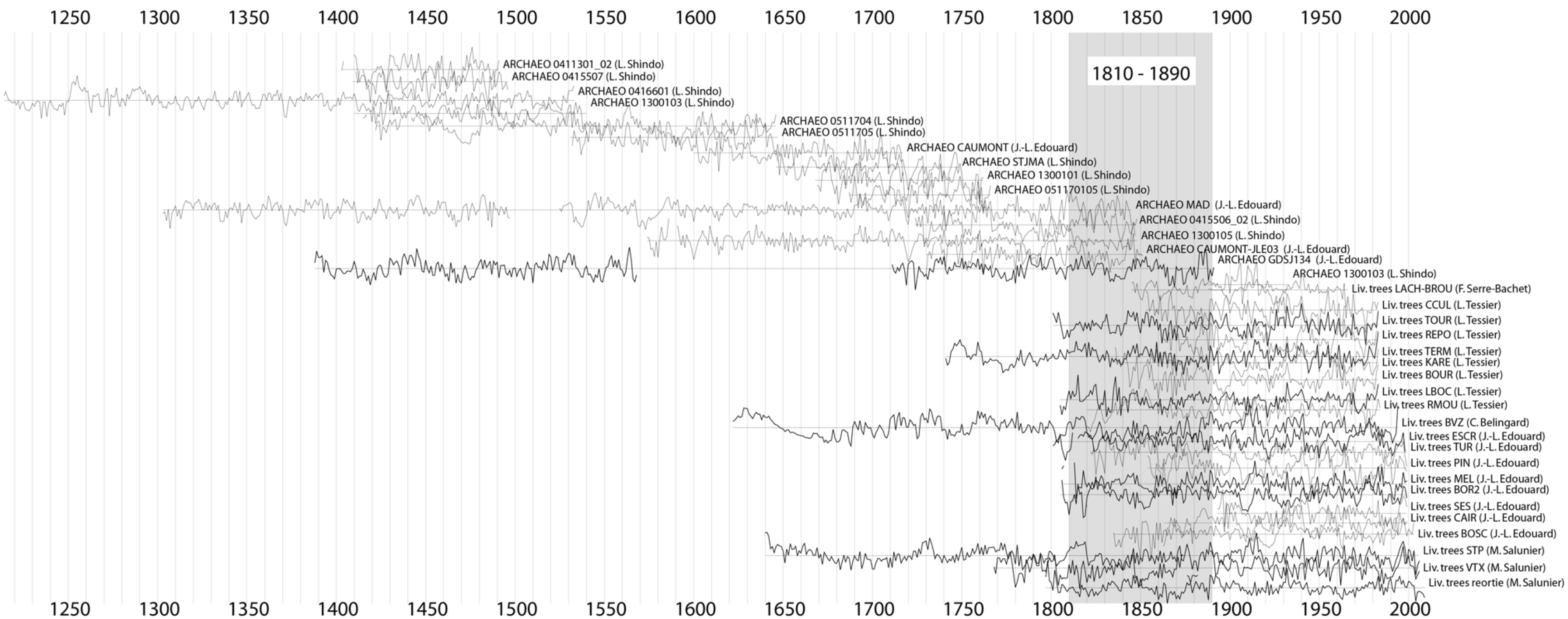

Figure 2

Chronology of the 14 archaeological sites (all from South-eastern France) and of the 21 living fir sites, indexation with the Corridor standardisation. The 11 chronologies covering the 1810-1890 period are in bold.

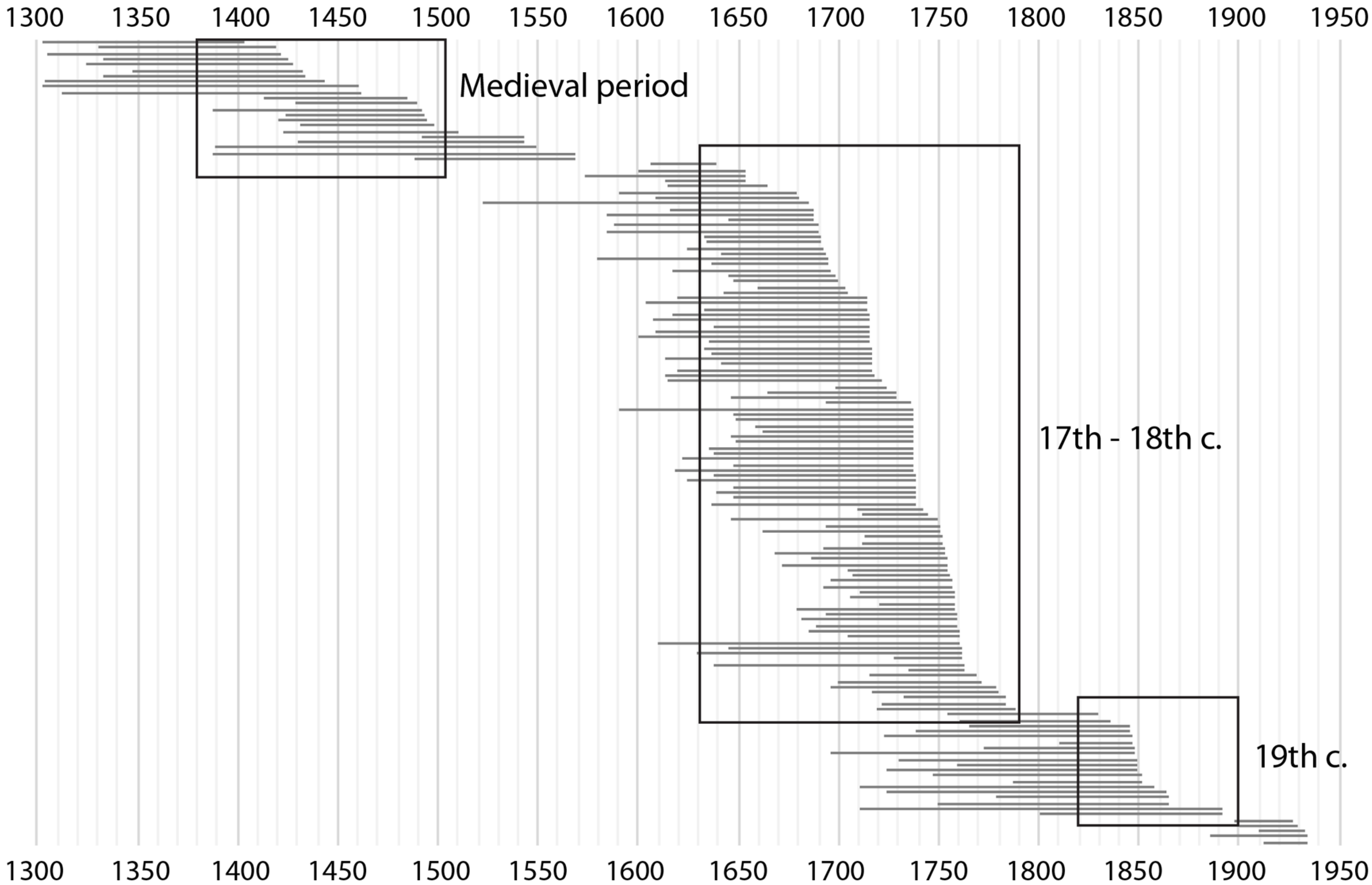

Figure 3

Diagram of the 144 dated fir series, showing three distinct construction phases.

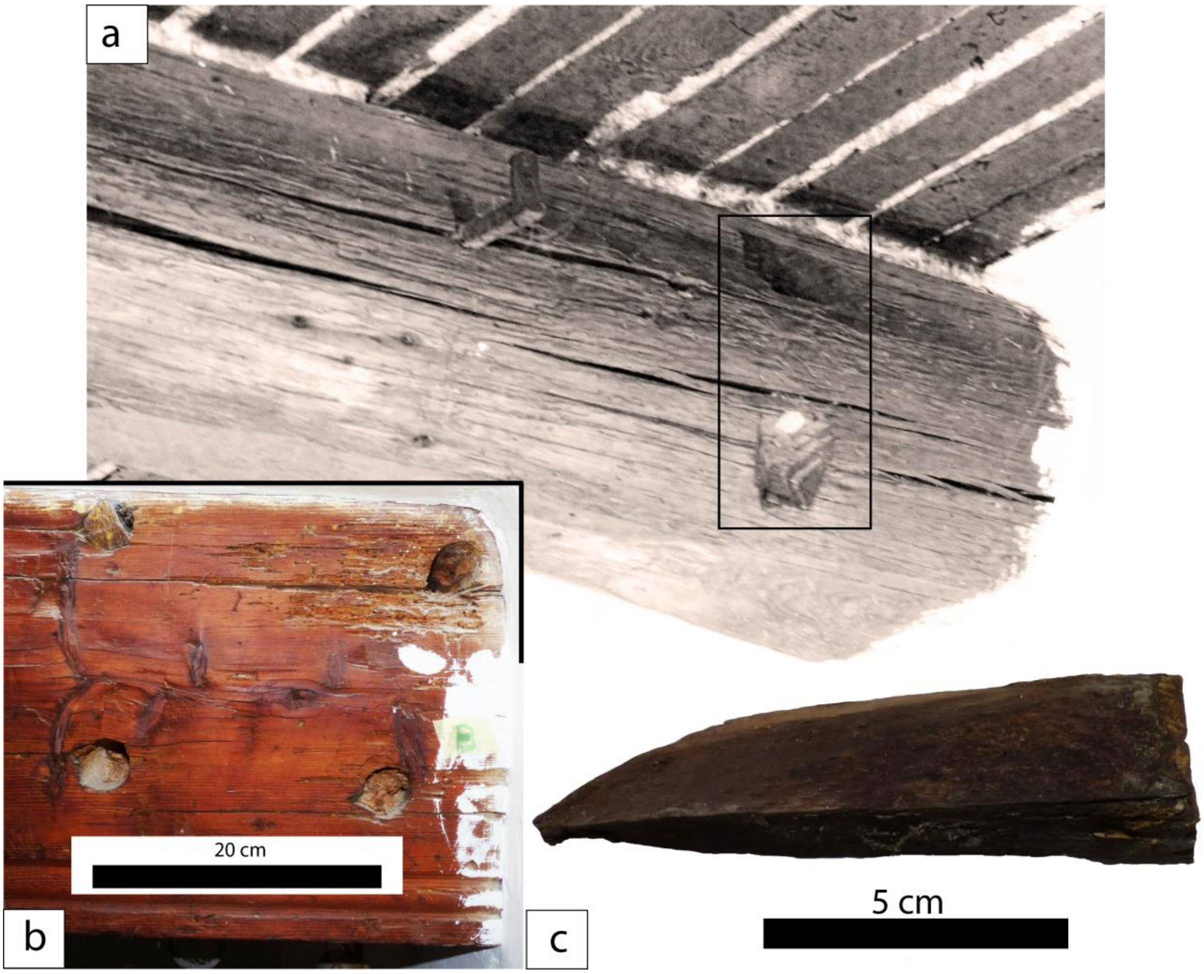

Figure 4

a- Undated joist with two triangle-shaped holes, b- Undated joist with four dowels arranged in a square, c- Detail of one of these dowels (*Fagus sylvatica*).

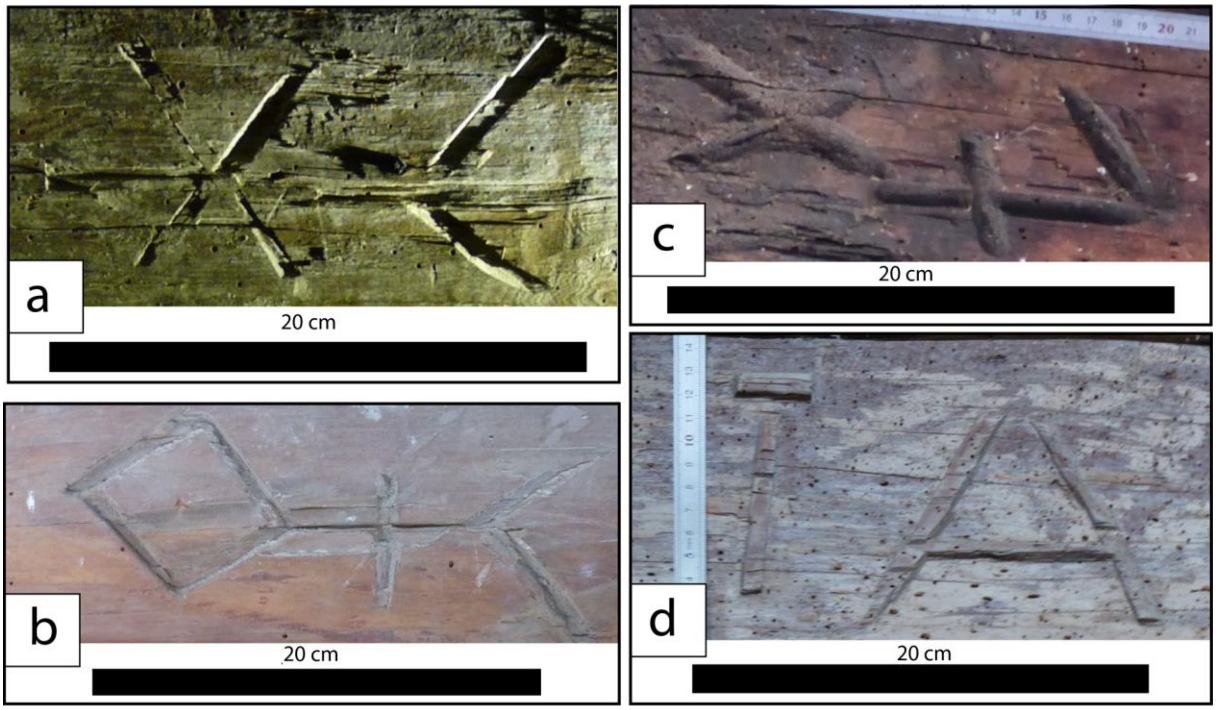

Figure 5

Geometric signs and letters carved on timbers. a- Grand-Saint-Jean castle, 1542, b- Caumont mansion, 1716, c- Le Seuil castle, 1489, d- Le Seuil castle, 1697.

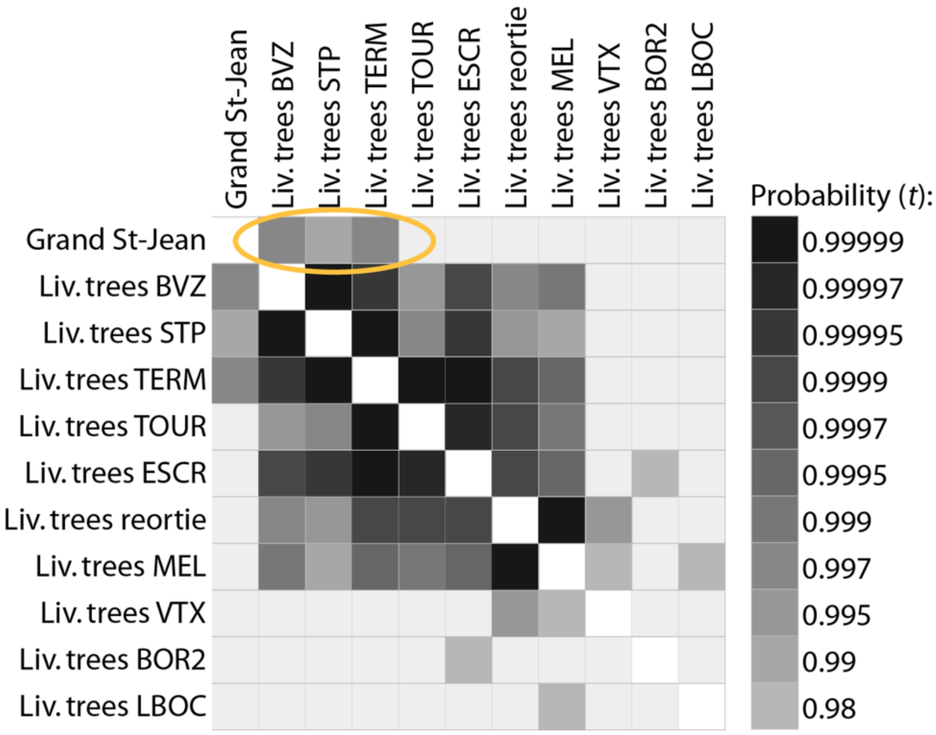

Figure 6

Square matrix of the t-value probability for the 11 correlated chronologies: 10 living tree ("Liv. Trees") chronologies and one archaeological site (Grand St-Jean), between 1810 and 1890. (matrix automatically drawn using the DENDRON-IV software, Lambert, 2011).
Chronology authors: C. Belingard (BVZ), J.-L. Edouard (BOR2, ESCR, MEL), L. Tessier (LBOC, TERM, TOUR), M. Saulnier (reortie, STP, VTX).

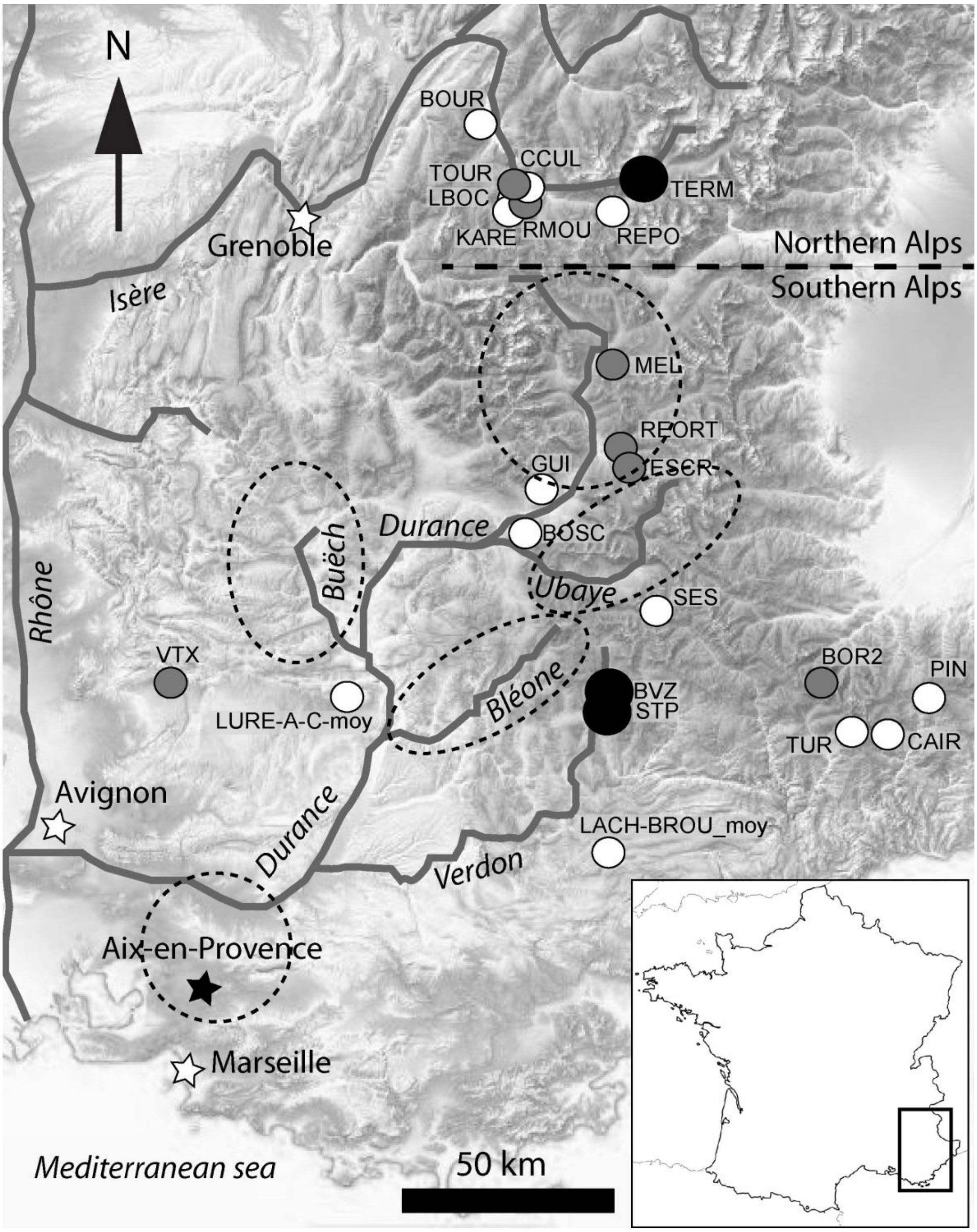

Figure 7

Location of the 22 living tree sites for the 1810-1890 dendroprovenancing case study, and the main watercourses (map: IGN scan25).

White circle: the chronology predate the 1810-1890 window; grey circle: the chronology covers the 1810-1890 window but does not synchronized with the Grand-St-Jean archaeological chronology; black circle: the chronology covers the 1810-1890 window and synchronized with the Grand-St-Jean archaeological chronology.

Bernardi's five supply areas for Aix-en-Provence city are circled with dotted lines (Grand-Buëch, High-Durance, Ubaye, Bléone and Aix region).

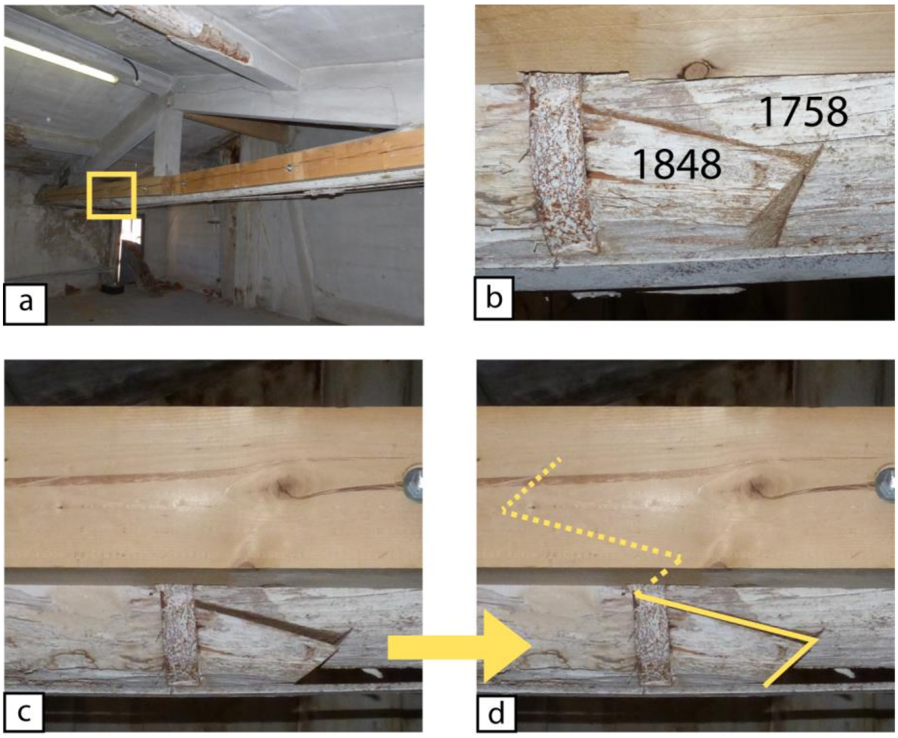

Figure 8

The tie beam of this truss consists of two beams (a and b), connected by a “Jupiter assemblage” (c and d). Today, a reinforcement plank partially hides the assemblage (doted lines on picture d) (Maynier d’Oppède mansion).

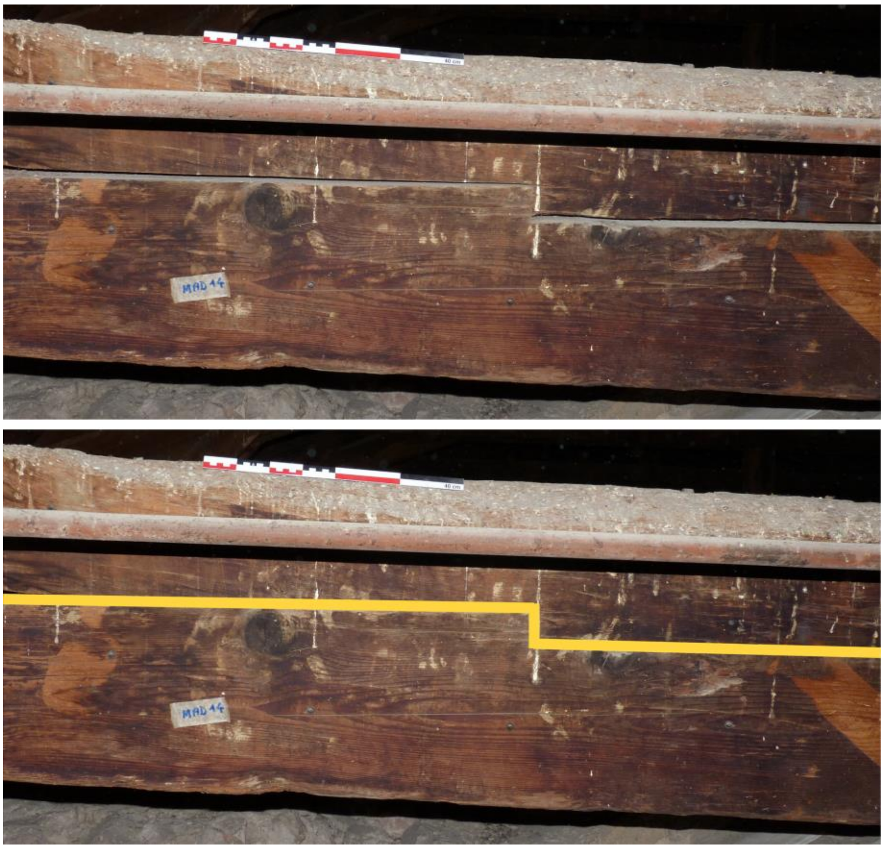

Figure 9

Details of the assemblage between the upper and the lower parts of a reinforced beam (Madeleine church).

Date of the first ring	Date of the last ring	Overlap	Probability /sécurity	Student *t.*	r (mean correlation coefficient)	Rank	Master chronologies
1303	1933	615	0.999995	8.95	0.32	1	centre_Blondel (archaeological woods, F. Blondel)
1303	1933	293	0.999995	8.83	0.42	1	STP (living trees, M. Saulnier)
1303	1933	311	0.999995	7.99	0.39	1	BVZ (living trees, C. Belingard)
1303	1933	230	0.999995	23.84	0.73	1	0416601 (archaeological woods, L. Shindo)
1303	1933	222	0.999995	10.85	0.53	1	STEREP (archaeological woods, J.-L. Edouard)
1303	1933	123	0.999994	8.11	0.53	1	0415506 (archaeological woods, L. Shindo)
1303	1933	82	0.999994	7.98	0.59	1	0411301 (archaeological woods, L. Shindo)
1303	1933	114	0.999992	6.99	0.5	1	MOUGINS (archaeological woods, J.-L. Edouard)

Table 1

Results of the mean fir chronology synchronisation with the master chronologies. Only the results with $t > 6$ are presented.