An example of interdisciplinary approach to the study of musical instruments: the case of the two viola *of the Quintetto Mediceo (1690) by Antonio Stradivari.*

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On the occasion of an exhibition held at the Galleria dell'Accademia in Florence, it was possible to examine in detail the two viola of the Quintetto Mediceo by Antonio Stradivari (1690), carrying out a further step in ascribing the alto viola owned by the Tuscan Foundation and preserved at the Library of Congress in Washington, to the Quintetto Mediceo. Beginning from the 18th century, only two instruments of the quintet remained at the Florence Court, while one was lost and the others changed ownership many times. Documentary and technical studies, inclined to identify the alto viola with the instrument in Washington, which was brought to Florence for the exhibition. Technological research on the belly of the alto viola and the tenor viola allowed to notice an anomaly in the spruce wood, suggesting the provenance of the two instruments from the same piece of spruce. Dendrochronological investigation confirmed the provenance of the wood of both viola from the same trunk and allowed to identify a possible dating of the last tree-ring to the year 1683.

Introduction

The Musical Instrument Collection of the Conservatorio di Musica "Luigi Cherubini" in Florence, on display at the Musical Instrument Dept. of the Galleria dell'Accademia since 2001, includes about five hundred instruments, and among them a nucleus of about fifty that belonged to the Grand-dukes of Tuscany, Medici and Lorraine. These were transferred directly from their Palace to the Conservatory in 1863, when Tuscany was annexed to the Reign of Italy, and are therefore richly and continuously documented through inventories, maintenance and administrative accounts and iconography from the time of their acquisition by the court – often directly from the maker – to our days.[1]
Two of the most relevant instruments of this group are a tenor viola and a cello made by Antonio Stradivari in 1690 expressly for Grand-prince Ferdinando de' Medici following a commission by Marquise Bartolomeo Ariberti. The tenor viola, in particular, is renowned for its exceptional conditions of preservation, presently being the only instrument by Stradivari surviving with original fittings (including bridge, fingerboard and tailpiece, and with the neck in the original position). Moreover the original drawings and models used by Stradivari to make the viola still survive in Cremona (Museo Stradivariano) enabling us to ascertain the complete authenticity of the instrument.

[1] A full reconstruction of the history of the collection and a description of the documents that survive for each of the instruments, collected and studied by Giuliana Montanari and Marco Di Pasquale, are published in *La Musica e i Suoi Strumenti: la collezione granducale del Conservatorio Cherubini*, ed. by Franca Falletti – Renato Meucci – Gabriele Rossi Rognoni, Florence, Giunti, 2001, in part. pp. 144-153.

The two instruments were part of a quintet (two violins, an alto and a tenor viola and a cello) that was described in the Medici inventory in 1700, but gradually underwent partial dispersion during the last quarter of the 18th century, under the reign of the Lorreine: the alto viola was recorded in 1776 for the last time, one violin is recorded as «lost» in the following year and the second violin, presently preserved in the collection of the Accademia Nazionale di S. Cecilia in Rome, was stolen by a court musician, Giovanni Felice Mosell, and sold to David Ker for the Hill firm in London in 1794.

The reconstruction of the path followed by the alto viola was, instead, more of a difficult task, since no certain document survives concerning its departure from Florence. However, a viola by Stradivari made in 1690 was acquired by a certain Mr. Bright of the London firm Norris and Barnes, and it is presently the property of the Tuscan Foundation and on loan to the Library of Congress in Washington. The instrument was hypothetically connected to the quintet in 1987 by Charles Beare on the basis of the exact dimensional correspondence to the drawings of the Museo Stradivariano.[2]

In the year 2001, on the occasion of the exhibition *Music at the Grand-ducal Court*, the surviving violin, the two violas and the cello were re-united and displayed together.[3] On the same occasion a documentation campaign and technological studies were carried out in order to further support, or confute the hypothesis that the so called «Tuscan» alto viola had been, in fact, part of the «Medici» quintet.

Fig. 1 – The instruments of the Quintetto Mediceo (1690), Galleria dell'Accademia, Firenze

[2] Charles Beare, *Capolavori di Antonio Stradivari*, (exhibition catalogue, Cremona, Palazzo Comunale, 1987), Milano, Arnoldo Mondadori, pp. 46-47

[3] *Music at the Grand-ducal Court*, ed. by Gabriele Rossi Rognoni, (exhibition catalogue, Florence, Galleria dell'Accademia, 2001), Florence, Giunti, 2001, pp. 48-53.

Technological examination

The technological examination of *Viola tenore* had confirmed, by means of microscopic observation[4], the use of Norway spruce wood (*Picea abies* Karst.) for the realization of the soundboard, and evidenced the particularity of chromatic variation between heartwood and sapwood of the wood used by Stradivari.
From technological point of view sapwood is the outermost part of the stem in trees, made by living cells (mostly in radial parenchyma) and physiologically active (conduction of living substances within the stem) at the time of the tree felling. Heartwood, on the opposite, represents the innermost part of the trees, and here all the cells are dead without any physiological activities.

Fig. 2 – Quintetto Mediceo: the tenor viola, 1690; Galleria dell'Accademia, Firenze

The limit between the two types of wood (transition zone) can be easily detected in some species (differentiated), where, heartwood can undergo to a colour transformation from the light colour of sapwood, to a different set of darker colours.
In many other species (undifferentiated), and Spruce is one of those, there is no difference in the colour of the two parts that uniformly maintain the light colour of the sapwood. In these species the limit of the two parts, still clearly observable in fresh wood, can be very hard to be detected, as during drying, wood normally assume the same colour.
The wood used for the soundboard of the *Viola tenore*, represents one of the very few cases, in which, the colour difference between sapwood and heartwood of the

[4] Fioravanti M., *Identificazione delle specie legnose*, in La Musica e i Suoi Strumenti: la collezione Granducale del Conservatorio Cherubini, ed. by Franca Falletti, Renato Meucci, Gabriele Rossi Rognoni, Florence, Giunti, 2001, pp. 125-126.

Spruce, is still present also after timber drying. This aspect observed and recorded during the technological observation of this instrument, was immediately evident during the matching of the two violas in occasion of the exhibition, suggesting the use of the same piece of wood for the realisation of the two instruments.

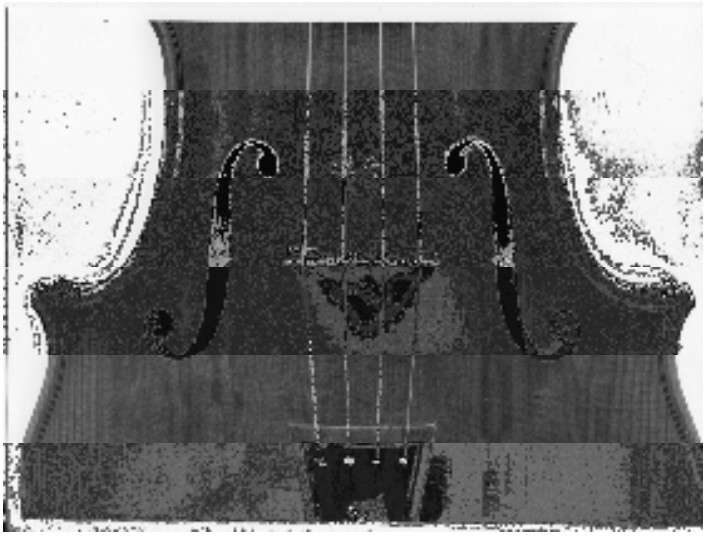

Fig. 3 – Quintette Mediceo: the tenor viola, detail of the belly

Dendrochronological investigations

In order to support the hypothesis emerged from the technological examination dendrochronological studies have been carried out with non-destructive method on both instruments, the tenor viola and the alto viola.
Dendrochronological data were obtained by direct measurement of tree-ring widths carried out *in situ* at the Galleria dell'Accademia with a PEAK hand-measuring lens to the nearest 0,1 mm. The measuring of each boards was carried out from the centre to the outermost part of the trunk along two different radii, in the area of the maximum lower width. As the wood was split radially, an almost complete sequence from the innermost to outermost ring of the log is present.
The collected data were edited and stored on a laptop (notebook), using the CATRAS© program[5], in order to proceed with a real-time check over the accuracy of the measurements. The curves from the different radii of each board were compared between themselves on the monitor allowing to carry out further measurements on areas of the wood with particularly narrow tree rings developed near the perimeter of the trunk.
Although measurements under a microscope with an appropriate device with accuracy to the nearest 1/100 mm, such as CCTRMD or LinTab, should be more advisable, direct measurements have proven to be accurate enough and satisfactory in many cases when working on musical instruments, on art masterpieces or archaeological remains[6].

[5] Aniol R.W., *Tree ring analysis using Catras,* «Dendrochronologia», 1, 1983, pp. 45-53.
[6] Klein P., *Dendrochronologische Untersuchungen an Gemaeldetafeln und Musikinstrumenten*, «Dendrochronologia», 3, 1985, pp. 25-44; Beuting M., *Holzbiologische und dendrochronologische Untersuchungen and Tasteninstrumenten* (Diplomarbeit Universität Hamburg, Fachbereich Biologie, unveroffentlicht), 2000; Martinelli N., Pignatelli O., *Datazione assoluta di alcuni relitti dal contesto delle navi di Pisa. Risultati preliminari delle indagini dendrocronologiche e radiometriche col ^{14}C*, «Gradus», 2008/Atti; Pignatelli O., *Dendrocronologia e archeologia navale* (The proceedings of the congress "Diagnostica e

The subsequent data processing were carried out in the laboratory: data were treated and stored using the CATRAS© and TSAP© programs[7]. Cross-dating was accomplished by visually checking the curves and by time series statistics, by calculation of well-established statistical parameters such as t_{BP}[8], GLK%[9], DateIndex (DI)[10] and percentage of agreement in pointer years[11] provided by the CATRAS© and TSAP© computer programs, according to standard dendrochronological procedures[12].
Furthermore the dendrochronological curves, obtained from the two boards of both bellies, were compared between themselves in order to get the mean sequence of each instrument. Then, the sequence of both instruments were compared between them to verify if the same spruce log was eventually used to create them, as suggested by technological investigations.
In the tenor viola the tree-ring sequence obtained from the bass side is 152 tree-rings long, while the one from the treble side is 149 tree-rings long. They cross-date «last tree ring to last tree ring» with excellent statistical values[13]; allowing to establish a single sequence of the belly. The processed mean tree-ring sequence has a length of 152 tree rings.
In the alto viola the tree-ring sequence obtained from the bass side is 169 tree-rings long, while the one from treble side is 153 tree-rings long. They cross-date «last tree ring to last tree ring» with high statistical values[14]; allowing to establish a sequence of the belly. The processed mean tree-ring sequence has a length of 169 tree rings.

	tree-ring sequence	**mean width**	**standard deviation**	**mean sensitivity**	**autocor**
Tenor viola	152	81.9	34.0	0.112	0.947
Alto viola	169	71.9	33.4	0.135	0.930

Visual and statistic comparison between the sequences from the two instruments, have shown that the curves established for the two violas (tenor viola and alto viola), have a highly similar pattern, confirmed by the significant high values of the statistical parameters: t_{BP} = 14.4, Glk = 77% with significance level of 99.9%, DI = 772. Although the two curves show some small differences regarding the number of tree rings (mainly due to operative difficulties founded in measuring the tree rings which were closer to the axial centre of the tree) the last tree ring of both curves does

conservazione di manufatti lignei», Marsala 9-11dicembre 2005), Firenze, Nardini, 2006; Pignatelli O., *Datazione del legno: le sculture* (The proceedings of the congress «Statue di legno. Caratteristiche tecnologiche e formali delle specie legnose», Perugia 1-2 aprile 2005), Roma, Poligrafico dello Stato, 2008, pp. 131-141.
[7] Aniol 1983, footnote n. 4; Rinn F., *TSAP Version 2.4. Reference manual*, typescript, 1996.
[8] Baillie M.G.L., Pilcher J.R., *A simple cross-dating program for tree-ring research*, «Tree-ring Bulletin», 33, 1973, pp. 7-14.
[9] Eckstein D., Bauch J., *Beitrag zur Rationalisierung eines dendrochronologischen Verfahrens und zur Analyse seiner Aussagesichereit*, «Forstw. Cbl. », 88, 1969, pp. 230-250.
[10] Schmidt B. 1987.
[11] Aniol R.W., Schmidt B., *Chronology development and analysis – Comment*, in Hughes et al., *Climate from tree rings*, Cambridge University Press, 1982.
[12] Baillie M.G.L., *Tree-ring dating and archaeology,* London – Canberra, 1982, pp. 1-274; Fritts H.C., *Tree ring and climate*, Academic press, London-New York-San Francisco, 1976, pp. 1-576; Cook E., Kairiukstis L.A., *Methods of Dendrochronology. Application in the environmental sciences*, Kluwer Accademic Publisher, Dordrecht, Boston, London, 1990.
[13] t_{BP} = 10.8, Glk = 72% with significance level of 99.9%, DI = 480.
[14] t_{BP} = 11.2, Glk = 71% with significance level of 99.9%, DI = 427.

match last ring to last ring. According to these results, and considering the dendrochronological characteristics of the curves elaborated from the two instruments, it is possible to claim that the boards used for the bellies were obtained from the same spruce log, as suggested by the technological study. Therefore the sequences of both instruments were averaged in a sequence 169 tree rings long.

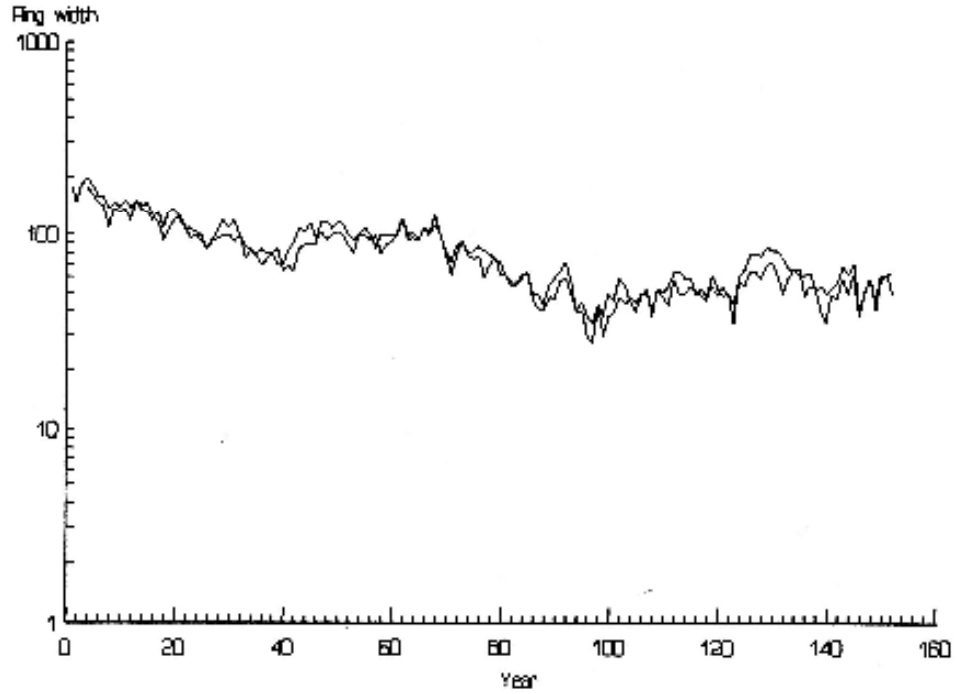

Fig. 4 – Quintetto Mediceo: the tenor viola, tree-ring sequences from the bass side and the treble side

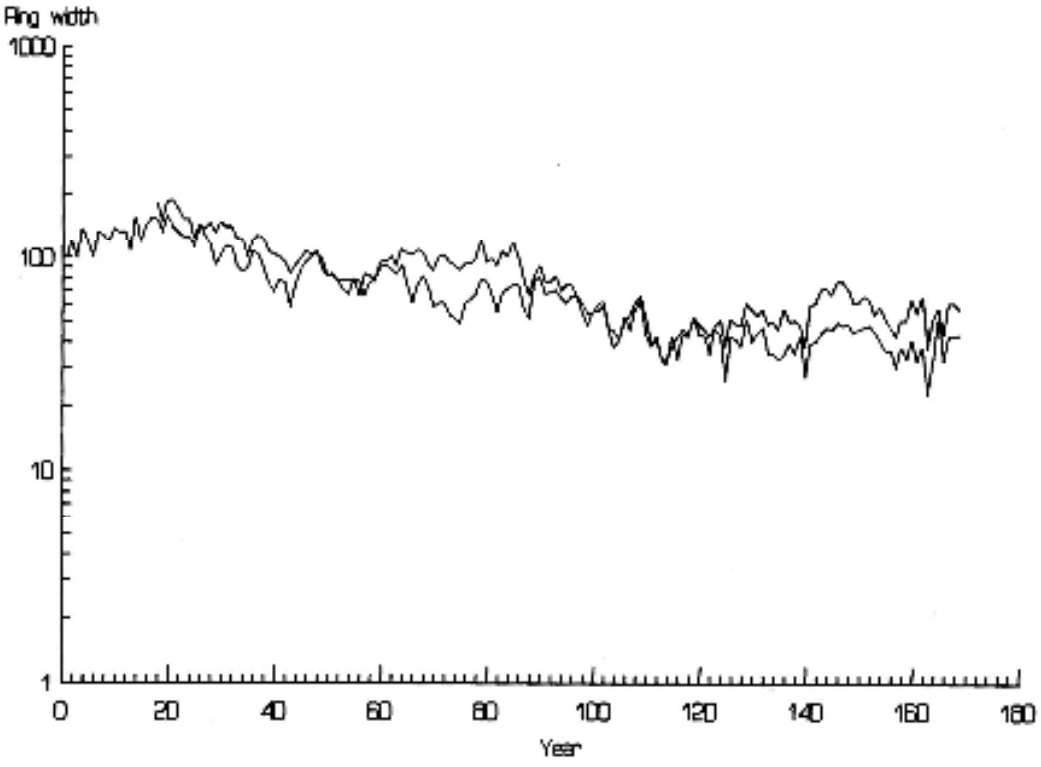

Fig. 5 – Quintetto Mediceo: tree-ring sequences from the bellies of the tenor viola and the alto viola

Although the dating of the musical instruments was not one of the aims of dendrochronology in this research - as the date of the group is well-known- anyway we decided to proceed in comparing the sequence from both instruments with the reference chronologies available for alpine spruce. The spruce reference chronologies used are the following:

- Oetztal chronology (Austria)(1276-1974 d.C.)[15];
- North-eastern Italy chronology (1362-1985 d.C.)[16];
- Veneto chronology for XIV-XVII centuries[17], formed by series obtained from the studies on architectural structures in Verona, Rovigo and Venice;
- Swiss Alps chronology (982-1976 d.C.)[18].

Cross-dating with the Tyrol spruce's master chronology identify a possible date, where the last preserved ring of the sequence corresponds to the year 1683[19].

Discussion

The dendrochronological date of the instruments was obtained against the Tyrol spruce's chronology. The result is consistent with the well-known date of the group *i.e.*1690, and highlights a 7 years gap, between the date obtained from the last annual ring measured on the top of the instruments, and the documentary evidence.
Present knowledge on the relationship between heartwood and sapwood in Norway spruce[20] does not add further information regarding the original dimension of sapwood and on the number of rings eventually removed during woodworking.
Anyway the gap between the year 1683 and the year reported on the label 1690 is consistent with the minimum till now reported «seasoning» period for Stradivari's instruments[21]. However we have to stress that defining the real seasoning period in musical instruments is very difficult because of the impossibility to identify with certainty the presence of the cambium.
Results of this research do not allow establishing the provenance of the wood used by Stradivari, because of the lack of a long chronologies network relevant to the southeast side of Italian Alps, being Norway spruce behaviour dependent from both altitude and microclimatic conditions of the different valleys[22].

[15] Siebenlist-kerner V., *Der Aufbau von Jahrringchronologien fuer Zierbelkiefer, Laerche und Fichte eines alpinen Hochgebirgsstandortes*, «Dendrochronologia», 2, 1984, pp. 9-29.
[16] Bebber A.E., *Una cronologia del larice (*Larix decidua *Mill.) delle Alpi orientali italiane*, «Dendrochronologia», 8, 1990, pp. 119-139.
[17] Martinelli & Pignatelli, unpublished data.
[18] Schweingruber F.H., Bartholin T., Schaer E., Briffa K., *Radiodensitometric-dendroclimatological conifer chronologies from Lapland (Scandinavia) and the Alps (Switzerland*), «Boreas», 17, 1988, pp. 559-566.
[19] t_{BP} = 3.9, Glk = 61% with significance level of 99.0%, DI = 88.
[20] Bernabei M., Piutti E., *Relazioni alburno-durame in tronchi di abete rosso (*Picea abies *Karst.) del Trentino*, «Monti e boschi», 5, 1999, pp. 31-36.
[21] Topham J., Mccormick D., *A dendrochronological investigation of stringed instruments of the Cremonese School (1666-1757) including* «The Messiah» *violin attributed to Antonio Stradivari,* «Journal of Archeological Science», 27, 2000, pp. 183-192; Burckle L., Grissino-Mayer H.D., *Stradivari, violins, tree rings, and the Maunder Minimum: a hypothesis*, «Dendrochronologia», 21/1, 2003, pp. 41-45.
[22] Grissino-Mayer H.D., Sheppard P. R., Cleaveland M. K., *A dendroarcheological re-examination of* «The Messiah» *violin and other instruments attributed to Antonio Stradivari*, «Journal of Archeological Science», 31, 2004, pp. 167-174.

Conclusion

The study carried out on the two violas led to reliably suggest that the instruments were indeed both part of the Medici quintet made by Stradivari in 1690 and that they were made of the same tree felled after 1683. The reliability of these results is based on the combined results of three different sources: documentary evidence, technological studies and dendrochronology.
Dating results obtained against the Tirol chronology - with significant, but not excellent values, have evidenced the needs of improving the database of chronologies for Norway spruce growing on the Italian alpine slopes, in order to reach longer temporal extension of the available chronologies, which in most cases do not reach the 16th century; this would not only allow a better dating reliability, but also allow a study of the dendro-provenance of the wood used by the most important Violin Makers.