Fig. 1, Plowden DG, top detail

Dendrochronology and its Application to the Strad3d study Instruments: Guarneri del Gesù's **Plowden,** and Stradivari's **Titian** and **Willmotte.**

Introduction

Dendrochronological analysis is a well established wood dating technique that has been shown to be a powerful tool in various areas of research (Baillie, 1982). It was discovered and exploited in early in the 20th century by an American scientist, A. E. Douglass, who initially used it to date timbers from houses found in early native American settlements in the south-eastern United States of America. In the field of musical instrument research it has found application in the dating of stringed instruments of the violin family (Klein, 1987;Topham and McCormick, 1998).

The construction of most modern members of the violin family involves the use of maple (Acer platanoides L.) or sycamore (Acer pseudoplatanus L.) for the back, sides and neck. The front however is generally made from Norway spruce (Picea abies (L.) Karsten) which as a result of its stiffness/weight ratio possesses the optimum acoustic properties. The making process usually results in a two piece front with a longitudinal join in the centre of the instrument, with the youngest growth rings coming together at the centre join (Topham and McCormick, 1998). It is the spruce front that is used for dendrochronological investigation as neither maple nor sycamore are suitable, due largely to their erratic growth (ITRDB Species List, 1995; Klein & Pollens, 1998).

Dendrochronology was first applied to stringed instruments nearly fifty years ago. A paper written by researchers working in Brunswick and published in Germany (Lottermoser & Meyer, 1958) laid down the technique of measuring the grain and displaying the data, but since they had no reference material they could not date the wood.

A number of authors since have successfully used dendrochronology to date a variety of instruments (Corona, 1980;Klein et al.1984;Klein, 1987). More recently a colleague and I have examined instruments of the violin family attributed to British and Italian makers of the 17th-19th centuries (Topham and McCormick, 1998, Topham and McCormick, 2000) and succeeded in dating many of them using Alpine spruce and larch reference chronologies. The second paper principally dealt with the controversial matter concerning the dating of Antonio Stradivari's 1716 violin known as 'Le Messie' or 'the Messiah' that resides at the Ashmolean Museum in Oxford in the UK. In addition to dating the instruments these studies provided some insight into the working practices of makers and possible sources of wood.

The main purpose for applying dendrochronology to violins is to find a date for the wood. Most makers today know exactly where their wood has come from and approximately when it was cut down. Sadly no such records, either written or verbal, exist for old instruments.

Dendrochronology offers a very precise method to establish the date of the wood and can give some indications where the wood came from. As some of you may know, the dating of wood on an old instrument can be useful in establishing the instrument's authenticity.

The technique relies on matching patterns of the grain found in wood from trees that grow in temperate climates. Since these trees experience a yearly seasonal change, growth rings are laid down every year. Due to climate variations, for example, changes in temperature and rainfall in different years, the width of the rings vary from year to year. It is this variation that is crucial to the pattern matching process.

The measurement of the three instruments and the results found.

In normal circumstances data, written as hundredths of a millimetre, is taken from the front of the instrument using portable equipment that achieves this accuracy with ease of use. The instrument is held static and a microscope is tracked across above the instrument's front where the ring-widths of the wood are recorded with the aid of a laptop computer. Data from this computer is transferred to a more powerful desktop computer where the analysis takes place.

The aim of the measuring process is to record the largest number of year ring widths present on the front of the instrument. This is often not achieved in one go. Cracks, inserted pieces, and more likely the set up of strings and tailpiece particularly on instruments of the violin family do not allow one continuous sequence to be measured. In these cases two, three or more sequences are measured in different parts of the piece on the front to encompass the entire set of year rings available. Since all these sequences are effectively from the same part of the wood, the data is compiled as a numerical average. This average then represents the whole set of year rings on the piece of wood under study and is the sequence that is used to test whether a date is obtainable. For the sake of brevity the recorded sequences, if more than one has been taken, are not presented in this report. Only the single or average numerical sequence has been given.

With respect to the three instruments in question, only photographs were available of the instruments. Although not ideal, remarkably accurate readings can be taken from photographs providing they of high resolution and if the varnish does not obscure the grain structure.

The photographs available of the three instruments showed the lower bouts of the front and the area between the f-holes, bridge and tailpiece that showed the grain up to the centre join.

As a rule readings are taken starting with the oldest year ring and finishing with the youngest. The identification of the oldest and youngest rings is found by inspection of the grain structure. The tree grows outward from the centre, laying down a ring of wood just under the bark each year. The end of the year's growth is marked by a sharp transition between each year's growth. The growth of the tree before the end of the year slows down and leaves a denser area just before the year end transition. This can be observed and the orientation of the grain can be established. In the case of all three instruments the oldest rings were located at the out edges of the front. First sets of readings were taken of the lower bouts from the edges of the tailpiece. The tailpiece obscured the rings toward the centre of the instrument. Turning to the photographs showing the areas between the f-holes readings were taken from the inside edge of the f-holes to the centre of the instrument. Again under normal circumstances using a stereo microscope, focusing on the surface of the front would render the strings sufficiently out of focus so as not to interfere with the clear reading of the width of the rings. However this was not possible with the photographs and estimates had to be made as to whether a ring was present under a string not. Consequently the final number of rings measured on both sides may differ by a ring or two to the actual number of rings present on the front. This would alter the date (if found) of the final ring by year or two.

Fig.2, Titian Stradivari top detail

However, the ring pattern on the photographs of the area between the f-holes of the Plowden and the Titian was actually very clear and it is highly likely that the number measured were the actual rings present on the fronts. The photographs of the Willmotte were not so clear. Not only was it difficult to estimate if year rings were present under the strings, the darkness of the varnish in the centre area made it difficult to distinguish some of the narrower rings. In this case the final ring number is an estimate and could differ from the actual number by up to 3 rings.

Table 1: Dates of the three instruments studied (The actual dates of the youngest rings may differ by a year or two particularly with the Willmotte, see text).

Instrument	Side	Number of rings measured	Date of Oldest ring	Date of Youngest ring
Plowden	Bass	67	1663	1729
	Treble	68	1662	1729
Titian	Bass	67	1631	1697
	Treble	75	1628	1702
Willmotte	Bass	77	1643	1719
	Treble	95	1619	1713

The data of all the readings from the three instruments were inspected and six meaned 'sequences' were established. These were 'cross-dated' against reference chronologies and dated sequences in a database that I have compiled over the past 12 years. The database currently holds data from nearly 2000 instruments, comprising nearly 4000 data sequences from the sides of the front of the instruments. The accompanying graphs (Graph 1, 2 & 3) show the sequences of all three instruments fixed in time. In the process of analysing the data from a violin front I often use graphs of the data to help determine a match. Measurements of the ring-widths are taken and plotted on the graph. The years are plotted evenly along the x-axis and the widths of the rings are plotted vertically on the y-axis. As plotted points, they would be difficult to see, so generally lines are drawn connecting the points. This makes it easier to see the variations over time. Some researchers tend to remove the points leaving only the lines which are then called 'curves'

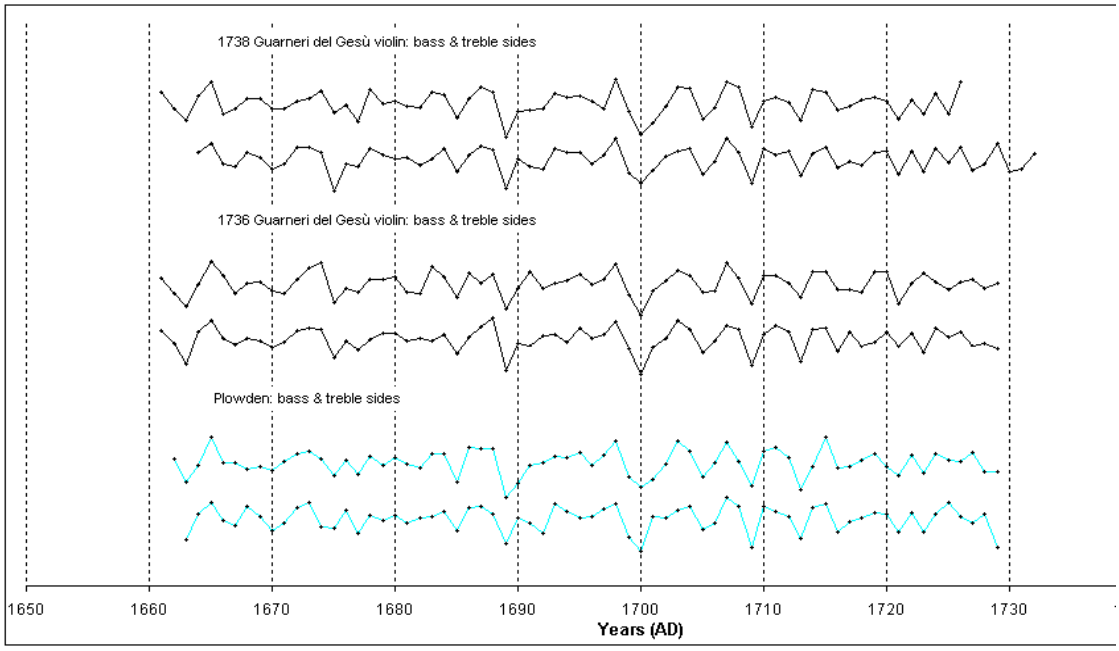
Bearing in mind that the actual dates may differ by a year or two, particularly with the Willmotte, the dates I found are given in Table 1. As can be seen the dates of the youngest rings are earlier than the known manufacture dates of the instruments and therefore consistent with the attribution of the instruments.

In addition, the sequences closely resemble sequences taken from other instruments by Stradivari and Guarneri as well as other makers. Graph 1 shows the sequences from the Plowden compared with sequences taken from two other Guarneri del Gesù violins. The similarity between the sequences of these instruments is enough to suggest the all three pieces came from the same tree. Similarly Graph 2 shows the sequences from the Titian compared with sequences taken from four other Stradivari violins. Again the similarity between the sequences of these instruments is enough to suggest the all three pieces came from the same tree. Finally Graph 6 shows the sequences from the Willmotte compared with sequences taken from one other Stradivari violin and one violin attributed to Guarneri filius Andrea. Here the similarity is not so close suggesting different sources for the pieces of wood used . ~ ~ ~

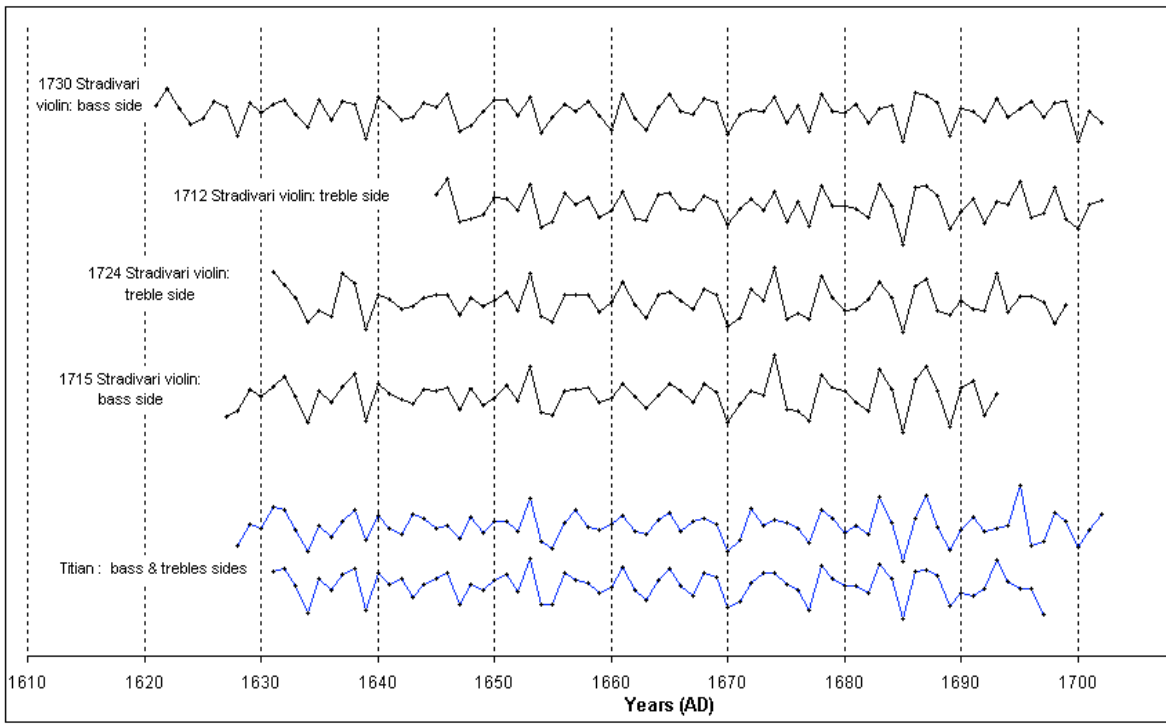
Fig. 3, Willemotte Stradivari, Top detail

Comparison Graphs

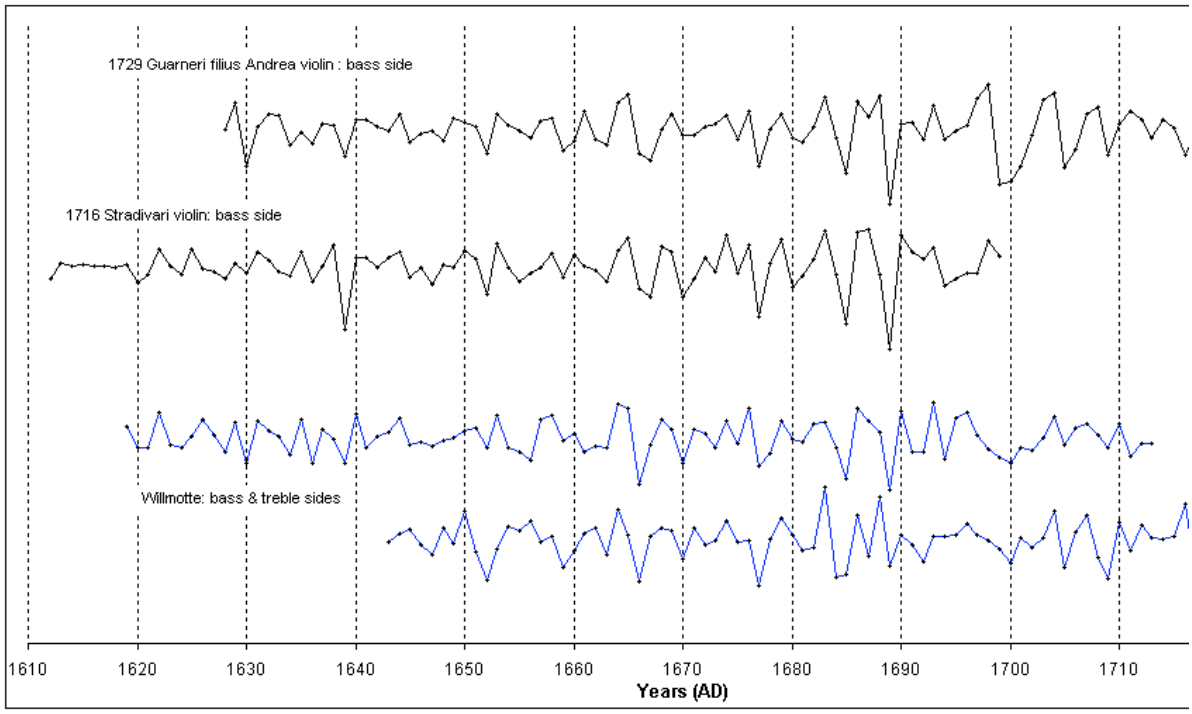
Graph 1, **Plowden** Guarneri



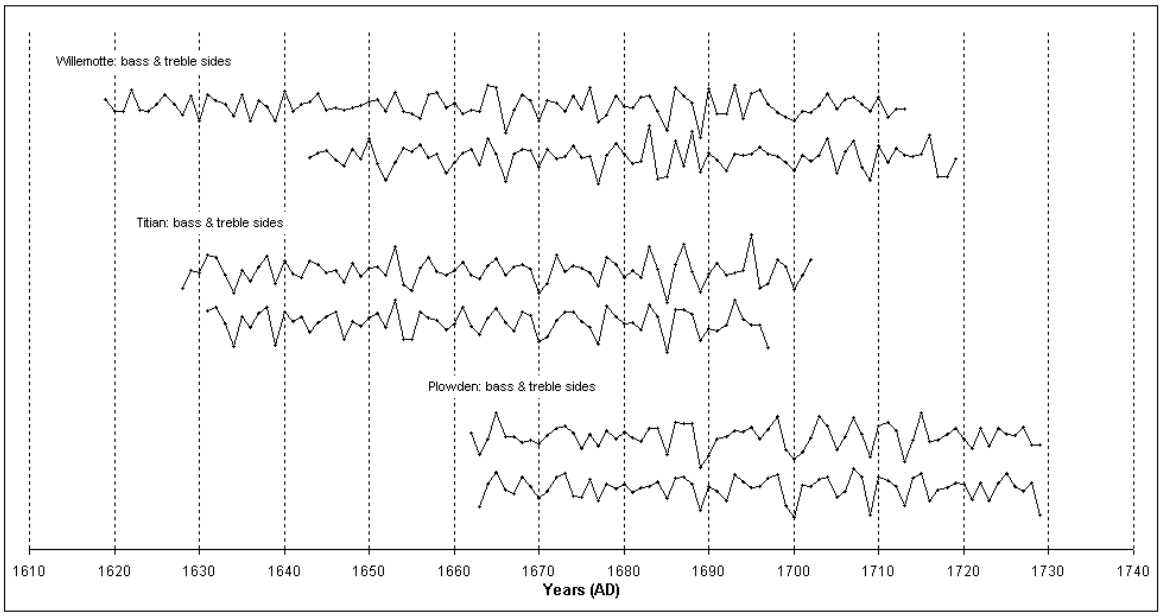
Graph 2, **Titian** Stradivari



Graph 3, **Willemotte** Stradivari



Graph 3, Compare All ~ Willemotte top**; Titian** Mid**; Plowden** bottom



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