CLIMATE CONUNDRUM

Did Stradivari have superior wood because of exceptionally low temperatures during his lifetime? JOHN WADDLE, STEVE ROSSOW and STEVE SIRR investigate the idea using CT scans of Cremonese instruments

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IN 2003 DENDROCHRONOLOGISTS LLOYD BURCKLE and Henri Grissino-Mayer proposed a hypothesis linking a period of exceptionally cold weather in Europe to acoustically unique and superior spruce used by Antonio Stradivari. They suggested that reduced solar activity from 1645 to 1715 – a period known as the Maunder Minimum – accentuated the cooling that had already affected the northern hemisphere since the onset of the 'Little Ice Age' in the 14th century, and led to slower-growing trees. Wood from these 'unique' trees should have closer grain lines and a higher density, thus giving Stradivari an exclusive opportunity never again to be matched by modern luthiers. Importantly and unfortunately, the authors did not report a single measurement of wood grain line spacing or density. Therefore, the Maunder Minimum hypothesis is untested and entirely conjectural. Until now.

Spruce and maple with narrow grain can be acquired in a variety of densities if one looks for it

We contend that many modern string musicians have been misled into believing that because this 'extraordinary' wood is no longer available, modern instruments have acoustical properties intrinsically inferior to the Maunder Minimum-period instruments of Cremona. This idea is being challenged on many fronts. Claudia Fritz and her team of fellow acoustics researchers, for example, have recently shown in rigorously constructed double-blind tests that some modern instruments can be tonally preferred to several violins crafted by Stradivari (see *The Strad*, February 2012).

THE BEST VIOLINS ARE MARVELS of engineering and there is not a gram of inessential material within the instrument. Each element is carefully crafted from the optimum material resulting in a complex acoustical device that performs with maximum efficiency. The choice of materials is made with three factors in mind: aesthetics, acoustics and function. Spruce is chosen for the top because it is lightweight, strong, flexible and beautiful. Maple has traditionally been chosen for the back for its beauty, stability and its ability to be carved.

A subject that hasn't been given much attention is the total weight of a violin. Musicians are sensitive to weight, and for good reason. A good player notices a difference of only one gram in a violin bow. Players are also sensitive to the total weight of the violin and quickly notice if an instrument is heavy or light. If a violin is heavy it is usually because the wood is too dense or too thick. This will have a dramatic effect on the acoustical quality of the instrument. In physics, a basic formula is F=ma where F is the force, m equals mass and a is the acceleration. How does this formula relate to violin making? If an object is heavier, ▹

COURTESY STEVE SIRR

FIGURE 1 CT scan comparison of virtual front plates of the 1704 'Betts' Stradivari violin (left) and a CT/CNC 'Betts' copy by John Waddle and Steve Rossow (right). The scans show a similar spacing between grain lines, which are narrowly spaced at the middle and widely spaced towards the edges

having more mass, it requires more force to get it to move. If it doesn't move, it can't be vibrating and if it isn't vibrating, it is not producing sound.

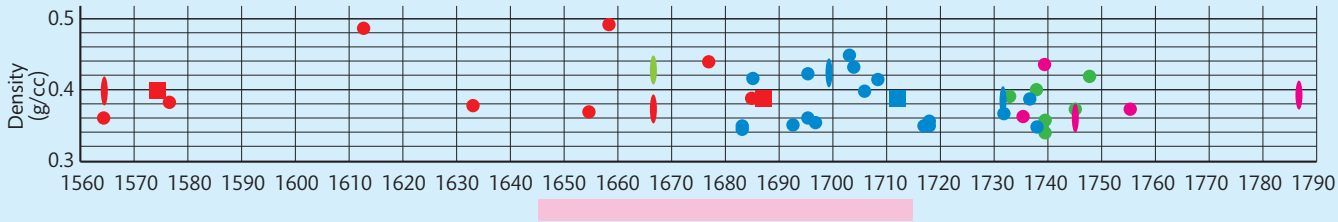
For many years we have been weighing violins as they came into our shops and recording the type of fittings, since fittings would be a significant part of the weight. After weighing hundreds of violins we are able to observe that the weight for complete instruments can range from 400 grams to over 500 grams. For an object that doesn't vary in size more than a few millimetres, a 20 per cent difference in weight is significant. We also notice that, with few exceptions, the heavier violins are less valuable student instruments and are less favoured by musicians. The lighter violins tend to be better quality and most preferred by musicians.

WE HAVE PREVIOUSLY DEMONSTRATED that CT scanning of stringed instruments gives us a valuable, non-invasive technique that reveals many hidden features (see *The Strad*, May 2010). We have also recently shown that CT provides an accurate method of measuring the wood densities of top and back plates.

It is rare to see a dense top with a low-density back, or a low-density top with a high-density back

It is true that Stradivari often, but not always, used narrow-grain spruce in his violins, mainly in the centre of the tops, as can be seen in a CT scan of the 1704 'Betts' Stradivari violin top (**figure 1**). However, many other violin makers – those contemporary with Stradivari, and after him – have also used spruce with narrow grain, as illustrated in the comparison CT

TOP-PLATE DENSITIES



BACK-PLATE DENSITIES

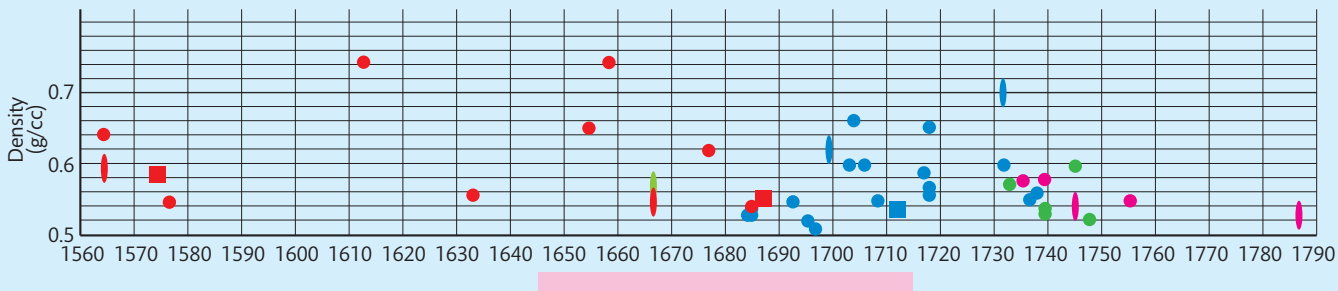


FIGURE 2 Timelines for virtual top-plate and back-plate densities of 34 violins, 7 violas and 3 cellos crafted by the Amati family, Antonio Stradivari, the Guarneri family and the Bergonzi family prior to 1790

scan of a CT/CNC-copied top of the 'Betts' made by John Waddle and Steve Rossow in 2012. We find that spruce and maple with narrow grain can be acquired today in a variety of densities if one looks for it, and it is not difficult for makers to measure the density of a piece of wood using common tools and methods.

In this current work we have analysed CT scans of 44 of the most valuable Cremonese instruments in the world and, after isolating the virtual tops and backs from the whole-instrument scans, have measured the densities of each instrument and placed these measurements on a timeline (**figure 2**). The average density for all top plates is 0.39 +/-0.04 g/cc and the average density of all back plates is 0.58 +/-0.05 g/cc. Timeline curves for top and back plate densities do not show increased density during the Maunder Minimum as predicted by Burckle and Grissino-Mayer. We believe the modern luthier, with some effort and attention, can acquire high-quality spruce and maple with similar densities as wood used in old Cremonese master instruments.

We also noticed that the densities of the top and back plates of individual Cremonese instruments showed a consistent pattern: it is rare to see a dense top with a low-density back, or a low-density top with a high-density back. This curious feature caused us to measure the density ratio of back to top plates for each instrument. We found that the average density ratio was 1:1.48 +/-0.15. Therefore, the master Cremonese luthiers have selected spruce and maple for each instrument so that the back density compared with the top density is about 50 per cent greater.

WHEN A MODERN LUTHIER sets out to make a new violin, decisions have to be made about design, wood and methods. The choice of wood is a major part of the process. Knowing the density of the woods used in the best examples of the violin making craft is helpful in deciding which woods to use. If making a copy, matching the density of the new wood to the old wood of the original will be important. Accurately carving the top and back plates for the copy is also important.

In conclusion, using X-ray CT scans of 44 Cremonese stringed instruments crafted prior to 1790, we find that the densities of the spruce and maple plates are similar to those of wood available to modern luthiers, and that the wood chosen by Stradivari varied from relatively low-density to high-density. We feel that although the Maunder Minimum hypothesis might have romantic appeal for some players, it cannot endure examination by modern technology. We hope this study will help assure string players that if they desire an excellent-sounding instrument, this can be achieved without first needing to win the lottery. ■