A remarkable, new Shroud dating measurement

By Michael Kowalski

Most people who know anything at all about the Shroud will be aware that a radiocarbon dating test of its fabric concluded that it dated from medieval times. That test was the first attempt ever made to directly measure the age of material taken from the Shroud and even though the result of that 1988 dating test contradicted a considerable amount of existing evidence that indicated the Shroud to be much older, the widespread view today is that the Shroud cannot possibly be authentic.

It's perhaps understandable that this radiocarbon age measurement might be considered more reliable than any of the pre-existing evidence. A measurement is, after all, usually considered to be the best way of confirming whether observation-based evidence is correct. For example, if we feel cold when indoors, we might check the temperature displayed on the central heating thermostat, or if clothes begin to feel a little tight, we might weigh ourselves to check whether we've put on a few pounds. This desire to confirm observational assessments by making a direct measurement was the main reason why leading Shroud scholars were vociferously calling for the Shroud to be carbon dated throughout the 1980s. Of course, that dating measurement contradicted a considerable amount of existing evidence but as far as most people are concerned, it provided the definitive verdict on the Shroud's age.

However, radiocarbon dating is no longer the only method which has been used to directly measure the age of Shroud material. Since the turn of the century, there have been five separate age measurements of the Shroud which have been made using alternative dating techniques. All these tests have been documented in peer-reviewed papers published in respected scientific journals, the most recent of which appeared as recently as March this year. This paper described how a team of Italian scientists led by Liberato de Caro had used X-Ray Spectroscopy to determine the age of the Shroud and like the other four alternative dating measurements, this gave a result which was much older than the radiocarbon date.

Recent dating tests

The reason why carbon dating can be used to date objects made from organic material is because the amount of radioactive carbon-14 relative to stable carbon-12 changes at a known rate. Radiocarbon scientists can determine what this ratio would have been when the plant or animal used to make the artefact was alive and so measurements of the current ratio can be used to calculate its age. However, scientists have discovered that flax, which is used to make linen, has other properties which also change over long periods of time. One such property is the presence of vanillin, a substance found in flax fibres which gradually disappears over time. Ex-STURP scientist Dr. Ray Rogers consistently found vanillin in fibres taken from medieval linen cloths but failed to detect it in samples taken from the 2,000-year-old Dead Sea Scrolls. He also failed to find vanillin in fibres taken from various parts of the Shroud, with the exception of fibres originating from the corner where the radiocarbon sample had been removed. His paper outlining his research was published in 2005, along with his conclusion that the Shroud must be at least 1,300 years old, considerably older than date of 1260-1390 AD assigned to it by the radiocarbon test [1].

Several years later, a team of Italian scientists led by Professor Giulio Fanti identified other characteristics of flax which could be used as a basis for dating measurements. The main constituent of flax is cellulose, which is a complex molecule which helps to give plants their strength and structure. Cellulose is formed from thousands of glucose molecules becoming joined together through the action of photosynthesis to form long chains, which tend to line up alongside each other to form an ordered, or crystalline structure. However, the cellulose in flax fibres degrades over time. For example, the bonds between the glucose molecules forming cellulose chains gradually break, decreasing the length of the chains. The parallel chains of cellulose also become increasingly disordered or amorphous, which gradually reduces the amount of crystalline cellulose.

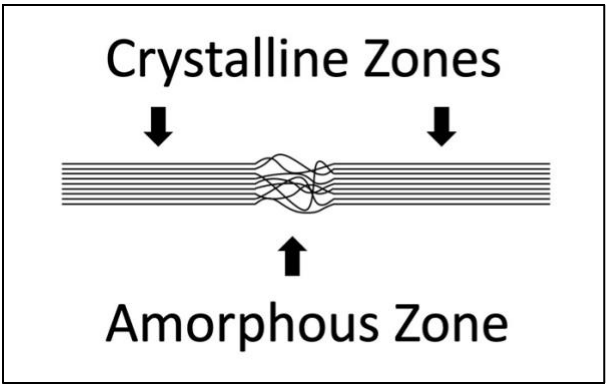

Figure 1. Representation of how cellulose chains form an ordered, or crystalline structure when aligned. Regions where the cellulose chains are disordered are referred to as amorphous.

This team of scientists found that it was possible to measure the extent of the molecular changes resulting from cellulose degradation using three different methods:

- *Infrared (FTIR/ATR) spectroscopy*: samples are exposed to infrared radiation of varying frequency producing a spectrum with downward spikes at specific frequencies where the radiation is absorbed. The intensity of these downward spikes produced by flax varied with the age of the sample [2].

- *Raman spectroscopy*: a single frequency laser beam, with a frequency in the range between ultraviolet and infrared, is directed at the sample. This produces a spectrum with peaks that indicate the sample's chemical composition and once again, the team found measurable differences in the spectra produced which varied with the age of the sample [3].
- *Mechanical analysis*: this involved the custom design and build of a tensile machine capable of measuring the minute stresses and strains on flax fibres under tension. The age of the fibres was shown to affect the physical properties of flax, such as the breaking load of fibres [4].

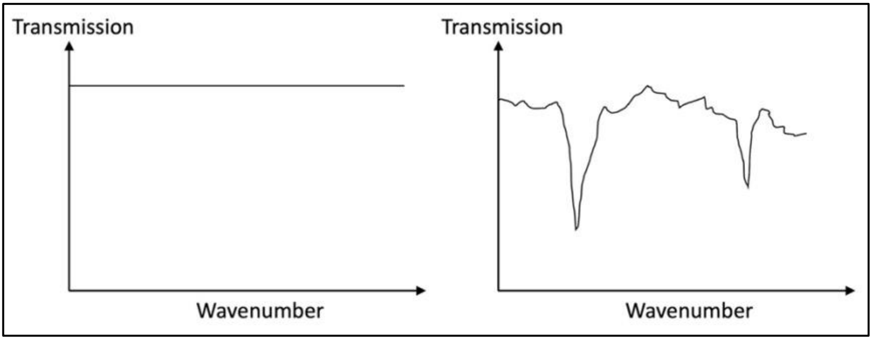

Figure 2. The left chart depicts the profile of the originating infrared spectrum before any absorption. The right chart depicts the resulting infrared spectroscopy spectrum showing downward spikes of varying intensity caused by molecular bonds in the chemical structure of the sample absorbing specific frequencies of radiation

All three of these methods were tested and calibrated using a range of flax samples taken from various new and ancient linen artefacts of known age. After successfully confirming the accuracy of these new dating methods by means of statistical tests of the results obtained, they were ready to use these methods to date samples that originated from the Shroud [5]. Like the Ray Rogers vanillin test, the results of all three of these new methods, which are shown below, indicated that the Shroud was much older than the date given by the radiocarbon dating.

DATING METHOD	**SHROUD DATING RESULT**
Infrared Spectroscopy	300 BC ± 400 years
Raman Spectroscopy	200 BC ± 500 years
Mechanical Analysis	400 AD ± 400 years
Mean Date	**33 BC ± 250 years**[1]

[1] All these date results were at a 95% confidence level

Dating the Shroud using Wide Angle X-ray Spectroscopy

During the last few years, a collaboration of Italian scientists led by Dr. Liberato De Caro has built upon the work of Giulio Fanti's team by investigating the use of another spectroscopic method for dating flax. This involved a technique known as Wide Angle X-Ray scattering, or WAXS. At certain wavelengths and incidence angles, X-rays are reflected and scattered by the lattice planes of crystalline material, producing a scatter pattern with peaks in intensity that reveal details of the material's crystalline structure. The crystalline zones in flax fibres, where the long cellulose chains are aligned, produce such a scatter pattern but slow chemical changes over hundreds of years break some of the links in the cellulose chains. This causes the cellulose structure to become increasingly amorphous, which produces measurable differences in the X-Ray scatter profile.

De Caro was able to experiment with the same set of linen samples of known age that had been used for Giulio Fanti's series of tests. He and his colleagues performed WAXS tests with several of these samples and found that there was a clear, linear relationship between scatter signal intensity and the age of the material up to an age of between 2,500 and 3,000 years. However, previous research into the degradation of cellulose had shown that the rate of chemical degradation was affected by environmental conditions, in particular temperature and humidity. This meant that some of these ancient samples would have degraded faster than others as a result of exposure to different environments and so an adjustment needed to be calculated and applied to each of the WAXS measurements to compensate for differences in average temperature and humidity.

De Caro and team therefore needed to be able to assess the historical temperature and humidity for the locations where each of their tested samples had been located. Fortunately, weather banks can provide over a hundred years of average temperature data for most regions and it was possible to use this data to make estimates of the historical temperatures to which each tested item had been exposed. They were also able to make a reasonable estimate of the average humidity as all the samples used in the test came from regions with a similar, semi-desert climate. The scientists were then able to use this information to make the measurement adjustments necessary to compensate for environmental conditions.

Some of the test samples were used to calibrate an equation calculated the sample age from their WAXS measurements, average temperature and relative humidity. This equation was then utilised to determine the age of the other samples, yielding impressive results. These results were remarkably close to the known age of the tested samples and the reliability of the equation was statistically confirmed by a regression analysis of the test results. This was clearly a positive outcome which confirmed the viability of this X-ray dating technique as a method of dating ancient linen fabrics [6].

The next stage of this research was to apply this new dating technique to a sample taken from the Shroud. This was a tiny piece of linen thread measuring 1 mm by 0.5 mm which came from an area of the Shroud close to where the radiocarbon sample had been taken. They performed WAXS tests to obtain the X-ray scatter profile for the Shroud sample and compared it with those produced by the ancient linen samples they had previous tested (fig. 3). It is visibly clear from this chart that the intensity of the signal peaks produced by the Shroud sample were almost identical to those produced by a sample found in the ruins of Masada, which was known to date from the period 55 to 74 AD.

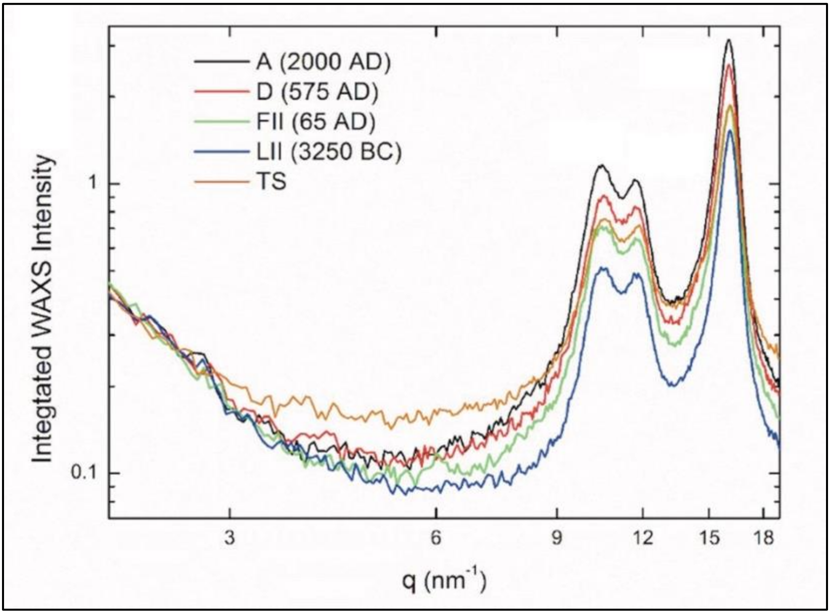

Figure 3. WAXS profiles produced by the Turin Shroud (TS) and four test samples. The intensities of the signal peaks produced by the Shroud sample are almost identical to that of sample FII, a first century linen fabric from an archaeological site in Masada. This visual comparison suggests that the two samples are of similar age. From X-ray Dating of a Turin Shroud's Linen Sample by Liberato De Caro et al., Heritage 2022, 5, 860–870.

However, the Shroud had been exposed to the heat of the Chambery fire in 1532 and it was clearly necessary to establish what effect, if any, this may have had on the scatter profile. The research team took a piece of linen and obtained WAXS scatter patterns before and after exposing the linen to temperatures of 200º centigrade for thirty minutes[2]. As expected, this heat exposure caused a distinct yellowing of the sample but made little difference to the WAXS pattern, which led them to conclude that the 1532 fire would not have affected the Shroud WAXS measurement.

The Shroud had also spent at least 700 years in France and northern Italy, which experience lower temperatures and higher humidity than the Judean desert where the Masada cloth was found. However, the net effect of these different conditions would have been a reduction in the rate of age-related cellulose degradation compared to the Masada sample. Assuming that in the Shroud had been kept at an average temperature of 22.5 ± 0.5º centigrade and an average relative humidity of 55 % during the preceding years, they calculated that the age of the Shroud would be 2,020 ± 80 years, a result which is clearly consistent with the cloth having originated from the time of Jesus Christ [7].

Summary

This recent X-Ray Dating of the Shroud has provided a result which is compatible with the findings of Ray Rogers, as well as the three dating methods pioneered by Giulio Fanti and his colleagues. However, not everyone is convinced that these innovative dating techniques can be expected to provide reliable results. They are still at a relatively early stage of development and so have not been thoroughly tried and tested, particularly when compared to radiocarbon dating. The world's leading radiocarbon laboratories are today using mature technology that has been refined by over seventy years of ongoing development. However, even the best technology will fail to work effectively if not used correctly and it's widely recognised that the 1988 radiocarbon test was severely compromised by poor management and flawed decision-making. One example is the lack of care taken over the choice of sample area and failure of those involved to address the risk of localised contamination. This contrasts sharply with the due diligence applied in the recent spectroscopic and mechanical dating tests to ensure that environmental factors and the effect of the Chambery fire were factored into their measurements.

It is understandable that the result obtained from this new dating of the Shroud should be greeted with a degree of caution. However, it is highly significant that this is yet another new dating method that has produced a result for the Shroud that not only contradicts the radiocarbon dating result but also supports claims that the Shroud

[2] Giulio Fanti's team had previously performed tests to determine the temperature that the linen fabric of the Shroud would have been exposed to in the 1532 fire. They took several samples of modern linen and heated each one in an oven, varying the exposure time and the oven temperature. The raised heat causes a yellowing of the linen fabric and by comparing the colour of the tested samples with the colour of the Shroud fabric, they were able to determine the most likely exposure temperature and time combinations.

originated in the first century. These methods may still be in their infancy but the consistency and mutual compatibility of the age measurements obtained by these innovative techniques is extremely impressive. Collectively, these five dating results provide remarkable evidence in favour of the authenticity of the Shroud that should not be overlooked.

References

1. Rogers, Raymond N. (2005). *Studies on the radiocarbon sample from the shroud of turin.* Thermochimica Acta, Vol. 425, Issues 1-2, pp. 189-194
2. Fanti, G. et al. (2013). *Non-destructive dating of ancient flax textiles by means of vibrational spectroscopy*, Vibrational Spectroscopy, Vol. 67, pp. 61-70
3. Ibid.
4. Fanti, G. and Malfi, Pierandrea. (2014). *Multi-parametric micro-mechanical dating of single fibers coming from ancient flax textiles*, Textile Research Journal, Vol. 84(7), pp. 714-727
5. Fanti, Giulio and Gaeta, Saverio (2013). *Il mistero della Sindone,* p72 (Rizzoli, Milan, Italy)
6. De Caro L, Giannini C, Lassandro R, Scattarella F, Sibillano T, Matricciani E and Fanti G. (2019). *X-ray Dating of Ancient Linen Fabrics*. Heritage. 2(4):2763-2783. https://doi.org/10.3390/heritage2040171
7. De Caro, L., Sibillano, T., Lassandro, R., Giannini, C. and Fanti, G. (2022). *X-ray Dating of a Turin Shroud's Linen Sample*. Heritage 5, No.2, 860-870. https://doi.org/10.3390/heritage5020047

o~o~O~o~o