The Shroud and Science

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Abstract

This paper will provide an overview of the most important, credible science that has been performed on the Shroud of Turin in the past century, including the 1988 radiocarbon dating that concluded the cloth was of medieval origin. It will then focus on the most recent published science that indicates the sample used for radiocarbon dating in 1988 was anomalous and did not represent the main body of the Shroud cloth.

The Shroud and Science

The Early Years

Most Shroud scholars accept that the first serious scientific interest in the Shroud of Turin began after Secondo Pia made the first photographs of the cloth in 1898. During a rare public exhibition of the Shroud, he used glass plates and a large camera on a scaffold to photograph the cloth as it was suspended in a frame above the altar of the Turin Cathedral.

Pia's photographs were the first major scientific contribution to the world's knowledge of the Shroud. Through them, we discovered that the Shroud image had properties similar to a photographic negative. He correctly observed that the lights and darks of the Shroud image are inverted, with dark highlights and light shadows. We are all used to seeing just the opposite (dark shadows and light highlights) when we look at a scene. Thus, when he first held up his negative of the face, he was confronted with the reversed or positive image of the man on the Shroud. He was the first person in history to see the natural rendition of the face of the man on the Shroud that we are all familiar with today. Sadly, Pia was promptly accused of fraud and manipulation by the skeptics of the day. It would take another thirty-three years before he was truly vindicated.

At the next public exhibition of the Shroud, in 1931, Italian photographer Giuseppe Enrie was given permission to photograph the Shroud again. He too used a large camera and plates, but with special orthochromatic, high contrast film and cross lighting that greatly enhanced the weave as well as the details of the Shroud's image. There was now no question that the properties of the Shroud image were just as Pia had described. At the same time, photography had proven itself to be an important tool for any future study of the Shroud.

After Enrie's photographs were widely distributed, new researchers were attracted to the subject and other disciplines became interested in the Shroud. In 1935, Pierre Barbet, a French physician, used cadavers to make the first significant examination of the Shroud from a medical point of view. His book, "A Doctor at Calvary," provided the first

insights into the medical and forensic aspects of the Shroud image. In 1938, Paul Vignon's book, "Le Saint Suaire de Turin devant la science, l' archologie, l' histoire, l' iconographie, la logique," became by far the most definitive work on the Shroud published up to that time.

In 1969, on the orders of Turin's Cardinal Michele Pellegrino, the Shroud's state of preservation was secretly studied by a team of experts. They examined, photographed and discussed it for three days, but did no direct testing. During this period, Giovanni Battista Judica-Cordiglia took the first color photograph of the Shroud.

In 1973, the Shroud was again secretly examined by a new commission of experts. For Professor Gilbert Raes were taken small samples of the Shroud's frontal end and side-strip, together with one warp thread and one weft thread. Dr. Max Frei, Swiss criminologist, took 12 samples of surface dust from the Shroud using adhesive tape. He later reported that pollens on these tape samples came from plants indigenous to Palestine.

Although serious scientific interest in the Shroud began soon after Secondo Pia made the first photographs of the cloth in 1898, and continued after Enrie confirmed Pia's observations with his new photographs in 1931, it was not until 1978 that the first truly in-depth scientific examination of the cloth itself was ever permitted.

The 1978 Scientific Examination

In 1976, researchers at Sandia Laboratories were using an analog device called the VP-8 Image Analyzer to help them extract details from x-rays. By inputting an image with a video camera, one could convert the subtle shades of gray in an x-ray film image into distinct steps of vertical relief displayed on an oscilloscope type monitor. At the request of several of their colleagues from Los Alamos National Laboratories and the Air Force Academy, they subjected a 1931 Enrie photograph of the Shroud to VP-8 image analysis.

The researchers were literally amazed at what they saw. Instead of the typical jumble of highlights and shadows obtained with other images, the image of the Shroud yielded a near-perfect relief of a human form. Since normal photography and art do not encode distance information into their final results, they wondered how the Shroud image could yield a perfect topographic (or 3-D) view of the man it depicted.[1]

These researchers included Dr. John Jackson, Dr. Eric Jumper, William Mottern, Don Devan and others. They were so fascinated with this new information that they decided to put together a team of scientists and researchers to try and determine exactly how the image on the Shroud was formed. In essence, that first VP-8 analysis became the catalyst for the creation of the Shroud of Turin Research Project (STURP). This diverse group of 33 volunteer American scientists and researchers, each a specialist in a related and necessary field, spent the next two years planning their tests and seeking permission to perform them on the Shroud.

In October 1978, after a public exhibition celebrating the Shroud's 400th anniversary in Turin, the STURP team was given five days and nights to perform a series of non-destructive tests and gather critical scientific data from the Shroud.

The team shipped 80 crates of instruments and equipment to Turin to perform their tests and moved it themselves into the Royal Palace. They spent the next 36 hours unpacking each case and assembling everything, including the special examination table they had designed and built specifically for the testing. They continued setting up their various experiments, and less than two days later, the public exhibition was over and the Shroud was removed from its display in the Cathedral and brought into the adjoining Royal Palace for the testing. The red silk covering cloth was removed and the scientists were finally able to take their first look at the Shroud. The cloth was then transferred from the wooden display board to the stainless steel examination table where it was held in place using magnets. The table allowed the Shroud to be rotated so it could be examined either vertically or horizontally.

Several European researchers opened the examination, starting with Dr. Max Frei, who took new sticky tape samples from the surface of the Shroud. He was followed by Prof. Pierluigi Baima-Bollone, who teased apart some threads and removed a few small sample fibers from the bloodstains on the back of the head.

Next, Prof. Giovanni Riggi, with the assistance of several nuns, separated a small section of the Shroud from its backing cloth. This allowed the first look at the underside of the Shroud in over 400 years. Riggi and his team then inserted a device to separate the two cloths and a vacuum was inserted between them to obtain dust and particulate samples. He next inserted an endoscopic camera system to photograph the underside of the Shroud. The endoscope's focusing light provided onlookers with the first documented view of the Shroud with light transmitted through the cloth, and several days later, I was given time to photograph the entire cloth with light passing through it.

Then the STURP team began their extensive tests. These included Infrared Reflectance Spectroscopy, Infrared Thermography and Infrared Photography as well as X-Ray Fluorescence measurements.

This was followed by UV Fluorescence and Reflectance Spectroscopy measurements taken by Roger and Marty Gilbert of the Oriel Corporation, a manufacturer of spectral instruments.

Ron London and William Mottern were responsible for X-ray radiography imaging. To ensure the exposed x-rays were not damaged in transit, they were processed immediately in an adjoining room of the Royal Palace, which made them available for inspection within an hour or so. A total of 43 low power X-rays were made during the event, an amazing number when one considers that each exposure required about 30 minutes.

Mark Evans used a special microscope to examine and photograph the Shroud at various magnifications. More than 30 photomicrographs were made of different areas of the Shroud. The dense blood at the small of the back is shown here at 32X.

Vernon Miller, STURP's Chief Scientific Photographer, along with Don Devan, an imaging scientist, photographed the Shroud using a number of different techniques, including the creation of a multi-image high resolution photo-mosaic and the use of color ultraviolet fluorescence photography. The resulting UV images provided a wealth of information, including the revelation of serum stains surrounding some of the bloodstains that are not visible to the naked eye or normal white light photography.

Ray Rogers of Los Alamos National Laboratories was head of STURP's chemistry group. He also took tape samples from the cloth for future chemical and microscopic analysis, but used a special torque applicator to control the amount of pressure applied to the Shroud and minimize the amount of pressure necessary to remove the tapes without damaging the cloth. The tape itself was custom formulated by 3M to leave no sticky residue on the Shroud and special well slides were used to keep the material on the sticky surface of the tapes from being pressed into the glue.

In addition to white light and transmitted light photographs of the Shroud, I was also responsible for documenting where on the Shroud each researcher had taken data or samples from. I used a magnetic marker system which ultimately allowed me to create a very accurate set of maps showing the test points for each of the STURP experiments.[2]

The work of the Shroud of Turin Research Project eventually resulted in the publication of 28 scientific papers, mostly in highly regarded peer-reviewed journals and formed the primary database of scientific information still used by Shroud researchers to this day. A detailed review of the 1978 STURP examination is available on the Internet[3] along with a complete listing of all STURP team members and their affiliations,[4] an overview of their conclusions[5] and a bibliography[6] of the papers they published.

The 1988 Radiocarbon Dating

Without question, the most controversial test done on the Shroud in modern history is the radiocarbon dating of the cloth performed by three independent laboratories in 1988. Prior to the testing, the experts held lengthy meetings to develop a credible protocol for taking multiple samples from the Shroud to ensure an accurate analysis, but unfortunately, that was changed at the last minute. In the end, only a single sample was removed from one corner of the Shroud, divided in thirds and delivered to three of the seven original laboratories that had precalibrated for the testing.

A critical chemical analysis of each sample was also required by the protocol, but was completely omitted from the testing by all three laboratories who claimed it was unnecessary since they "knew the samples came from the Shroud." In a peer-reviewed journal a few months later,[7] they unanimously proclaimed the Shroud was medieval in origin to a 95% certainty, in spite of the large amount of other credible science that

pointed to the cloth being much older. Sadly, the international media instantly proclaimed the Shroud a medieval "fake" and most serious Shroud research around the world came to an abrupt halt that lasted for over ten years.

Shroud Science in Limbo

The vacuum left by the c14 dating and the immediate cessation of most serious Shroud science brought forth new researchers with theories that could only be called "pseudo-science." In almost every case, these novice so-called researchers accepted the carbon dating results and invented new theories to provide explanations for how the image was manufactured in medieval times. One example is the infamous "Leonardo" theory, which stated that the Shroud image was produced by the famous artist using a camera obscura. Of course, the results were very different than the Shroud image and they failed to mention that the Shroud was documented in the historical record a full 100 years before Leonardo was even born!

At the same time, some serious researchers did try to develop theories as to what went wrong with c14 dating itself. Some suggested that the heating of the Shroud in the 1532 fire had skewed the date, although that possibility was denied by the radiocarbon labs that performed the tests. Another broadly publicized theory proposed that there was a "bioplastic" coating on the fibers of the Shroud deposited by bacteria that had skewed the results. However, this work was published in the form of a commercial book rather than in a scientific journal. In the end, none of these theories were supported by any scholarly published research.

Shroud Science Returns

In 2000, researchers Sue Benford and Joseph Marino presented a very controversial paper at a major international Shroud conference held in Orvieto, Italy.[8] They claimed that the sample used for c14 dating in 1988 was actually from a repaired and rewoven area that did not represent the main body of the Shroud cloth. They also provided some very convincing evidence, including corroboration by several independent textile experts that had examined closeup photographs of the 1988 c14 samples. They concluded that the sample area had been rewoven in France using "invisible mending," a technique perfected by the French court in the 14th century, and which added newer material to the cloth that skewed the resulting date. In 2002 they presented two additional papers with additional support for their theory[9] [10] and, although their work was certainly considered interesting, it was basically still ignored by most Shroud scholars. All of these papers were published on the Internet and eventually, they were read by former STURP team member and chemist Ray Rogers.

Rogers' initial reaction was that the Benford/Marino theory was nonsense and he could prove them wrong in 5 minutes. However, after reexamining the 1973 Raes sample and 1978 Shroud samples in his own collection, he made a startling discovery that led him to restart his own research. Under careful microscopic examination, he found an end to end splice in the Raes sample, which actually corroborated the Benford-Marino theory. After

studying this sample, which was taken from an area immediately adjoining the 1988 c14 sample site, he needed to test some portion of the actual c14 sample to be certain of his conclusions. In 2004 he obtained an actual reserve portion of the 1988 c14 sample itself, which allowed him to complete his research and ultimately led to the publication in January 2005 of a new paper in the peer-reviewed chemistry journal *Thermochimica Acta*.[11]

The paper, titled, "Studies on the Radiocarbon Sample from the Shroud of Turin," made the following observations.

- The lignin at growth nodes on the Shroud's flax fibers did not give the usual chemical spot test for lignin using vanillin as an indicator. Preliminary estimates of the kinetics constants for the loss of vanillin from lignin (found in all plant materials) indicated a much older age for the cloth than the radiocarbon analyses. The older the linen, the less vanillin is indicated when a sample is tested. The Holland cloth and other medieval linens gave a clear test for vanillin, as did the Raes and c14 sample. The fact that vanillin cannot be detected in the Shroud, the Dead Sea Scrolls and other very old linens, indicates the Shroud is quite old itself. He concluded that the majority of the Shroud cloth was manufactured using the ancient method (as described by Pliny the Elder), but not so for the Raes and c14 sample areas.

- Chemical and microscopic analysis of both the Raes and c14 samples revealed an encrusted plant gum coating on the surface of the fibers with Madder root dye particles embedded in it. The dye apparently was applied after the cloth was rewoven in an attempt to match its color to the Shroud. Chemical analysis of both the Raes and c14 samples revealed the presence of alizarin dye and red lakes, indicating the color in these areas had been manipulated. The dye found on the radiocarbon sample was not used in Europe before about A.D. 1291 and was not common until more than 100 years later.

In an effort to obtain additional data, Rogers sent portions of the Raes sample to independent microscopist John Brown for further examination. Brown found that when the warp threads are removed from the weft threads, undyed areas are revealed, supporting Rogers' conclusion that the dye was added after the reweaving. Also, UV fluorescence microscopy revealed that the undyed areas do not fluoresce like the dyed areas. His photomicrographs reveal that the outer surface of many fibers showed the characteristic encrustation of gum and dye particles. He also used a scanning electron microscope to create high magnification images that further revealed the encrustation of gum and dye particles.

Rogers had also observed cotton fibers interwoven with the linen in the Raes and c14 samples and this was corroborated by John Brown's photomicrographs. In fact, cotton was even reported by one of the radiocarbon labs in 1988, but was ultimately disregarded as unimportant. No cotton was found anywhere else on the Shroud. Rogers believed that the cotton was used to make the repaired area easier to dye and match it to the color of

the rest of the cloth. Typically, linen has a waxy outer surface and does not hold dye very well. Cotton was often interwoven with linen to make such dyeing possible.

Conclusions

Based on the preliminary research by Benford and Marino and this important peer reviewed scientific paper by Ray Rogers, we can now reasonably conclude that the sample used for the 1988 radiocarbon dating of the Shroud of Turin was anomalous and did not represent the main body of the Shroud cloth. The c-14 test results that declared the cloth medieval in origin should be set aside due to the use of an invalid sample.

Sadly, Rogers died only six weeks after his paper was published. His final work became his most important contribution to Sindonology and is arguably the most important single piece of Shroud science completed in the past 20 years. It clearly demonstrates the importance and the necessity of applying careful empirical science in any future Shroud studies. In spite of its occasionally inconsistent history, the relationship between the Shroud of Turin and modern science is alive and well and holds great promise for the future.

A detailed history of the Shroud from 1349 to the present day is available on the Internet at the following link: http://www.shroud.com/history.htm.

[1]**Endnotes** (See links for complete references)

[1] An Overview of the VP-8 Image Analyzer http://www.shroud.com/78strp10.htm
[2] Barrie Schwortz, "Mapping of Research Test Point Areas on the Shroud of Turin," http://www.shroud.com/mapping.htm
[3] An Overview of the 1978 STURP Scientific Examination http://www.shroud.com/78exam.htm
[4] The 1978 STURP Scientific Team http://www.shroud.com/78team.htm
[5] STURP's Conclusions http://www.shroud.com/78conclu.htm
[6] A Bibliography of STURP's Published Papers http://www.shroud.com/78papers.htm
[7] The 1988 Radiocarbon Dating Paper http://www.shroud.com/nature.htm
[8] Marino & Benford's "Evidence for the Skewing of the C-14 Dating of the Shroud of Turin Due to Repairs" http://www.shroud.com/pdfs/marben.pdf
[9] Benford & Marino's "Textile Evidence Supports Skewed Radiocarbon Date of Shroud of Turin" http://www.shroud.com/pdfs/textevid.pdf
[10] Benford & Marino's "Historical Support of a 16th Century Restoration in the Shroud C-14 Sample Area" http://www.shroud.com/pdfs/histsupt.pdf
[11] Ray Rogers' "Studies on the Radiocarbon Sample from the Shroud of Turin," Thermochimica Acta 425 (2005) pp.189-194. http://dx.doi.org/10.1016/j.tca.2004.09.029