Textile Evidence Supports Skewed Radiocarbon Date of Shroud of Turin

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ABSTRACT

The most studied artifact in human history is the Shroud of Turin, a 14 by 3.5 foot sheet of linen with lightly-shaded ventral and dorsal images of an apparently crucified man matching the wounds reported to have been incurred by Jesus of Nazareth. In 1988, Carbon-14 (C-14) dating of a corner section of the cloth produced dates ranging from 1260 to 1390 A.D.(1) This paper presents new evidence demonstrating that it is highly probable that the C-14 samples were not characteristic of the main Shroud and were spurious.

Introduction

On August 28, 2000, at the Worldwide Congress "Sindone 2000" in Orvieto, Italy, the paper entitled, "Evidence for the Skewing of the C-14 Dating of the Shroud of Turin Due to Repairs" was originally presented. (2) This paper proposed a hypothesis that a “patch” of material, from the 16th Century, was skillfully spliced into the 1st Century original Shroud cloth in the C-14 sample used by the laboratories for testing; thus, altering the date to make it appear more modern than the main Shroud. Several supporting arguments were provided in this paper. Among these arguments included calculations performed by Beta Analytic, the world’s largest radiocarbon dating service, that the observed proportion of medieval material in relationship to assumed 1st Century material, matches the findings of the AMS Labs in 1988. Second, the paper reported the

results of three blinded reviews of photographs of the uncut C-14 sample, and one of the sub samples, by independent textile experts. All of the experts reported seeing what appeared to be aberrant weaving on one side of the sample. Third, the paper proffered an historical interpretation of why the area had been patched in the 16th Century. Finally, a review of the statistical analysis of the dates obtained by each of the three AMS Labs, as they relate to the sample's distance to the edge of the cloth, was shown to produce a nearly identical angle as the observable angle delineating the two disparate weave patterns in the C-14 sample.

This paper was critiqued by many of the world-renowned radiocarbon experts involved in the 1988 dating of the Shroud. Included in the review process were: Dr. Timothy Jull, Editor of the journal Radiocarbon; Harry Gove, IsoTrace Laboratory, Department of Physics, University of Toronto; Paul E. Damon, University of Arizona radiocarbon laboratory; Jacques Evin, Centre de Datation par le Radiocarbone; Gabriel Vial, Professor at Institut des Textiles de Lyon; Prof. Franco A. Testore, Torino, Italy; textile expert Mechtild Fluery-Lemberg; archaeologists, William Meacham and Paul Maloney (3); and former STURP member and chemist Dr. Ray Rogers (4, 5). Dr. Rogers has in his possession both main Shroud and Raes sample threads, which enabled him to test the hypothesis posited in the paper.

The purpose of this paper is to: 1) address the concerns raised by the above referenced reviewers; and 2) to provide new evidence garnered since the paper's original presentation supporting the 16th Century "patch" hypothesis. Extensive and compelling data are now available to successfully demonstrate that an incorrect medieval dating conclusion was made concerning the Shroud of Turin.

Concerns raised by reviewers

In providing a summation of reviewers' comments, Dr. Jull offered the following: "1. The paper asserts that the dates for the sample can be explained by a section of cloth sewn into an adjacent (older) cloth. It is stated this addition is invisible. The authors assert this can explain the differences in ages between the 3 radiocarbon labs, which dated the Shroud. This assumes several things, including that the radiocarbon labs homogenized the entire sample they received. Further, Gove indicates the calculation given by Mr. Hatfield is incorrect and in any case, this calculation is based on an unprovable hypothesis.

2. Several reviewers (Damon, Evin, Testore, Vial) state that the added piece of cloth on one side of the Shroud was clearly visible and avoided. This is stated most clearly by Testore, who writes, 'the carbon samples represented the bulk of the Shroud and the hypothesis based on the influence of repairs on the datation has no fundament [sic] . . .'

3. The paper does not appear to add anything new to the scientific discussion of the Shroud. Several reviewers suggest it only causes confusion by adding 'subjective' material and assumptions not based on direct or indirect measurements, or demonstrable historical evidence.

4. Several reviewers argue that *Radiocarbon* is an inappropriate place for a speculative article about dating of the Shroud.

5. From my own perspective, I would remind you that your hypothesis requires that the samples in each lab were combined together, whereas I know that in our lab at least, the samples were cut into smaller fragments, which were dated independently. I think this was also done at Zurich. I am not sure what was done at Oxford."

In his individual review, Gove asserts, “A mixture of 60% 1500 AD cloth and 40% 75 AD cloth by mass gives a date of 665 AD, not 1210 AD as claimed by Beta Analytic.” (Gove). Further, Vial and Testore declare, “We carefully inspected the shroud and we are sure that this sampling place was representing the whole shroud.” (Vial) “I examined carefully the cloth all along the warp and filling of the threads concerned, without noticing any splicing.” (Testore)

In addition to the summary comments provided by Jull, another concern raised by Damon, and expressed by other independent reviewers (Fluery-Lemberg, Meacham, Maloney), was the credibility of the claim that 16th Century European weavers could repair a textile with an “invisible” patch. This concern also needs to be satisfactorily addressed.

Response to Concerns

Calculation by Beta Analytic:

Three main lines of supporting data demonstrate the veracity of the hypothesis that approximately 60% of the C-14 sample represented 1500 AD threads while approximately 40% represented 1st Century threads, thus resulting in C-14 dates between 1260 – 1390 AD. First, the percentage of aberrant (patch) threads was selected based upon visual examination of a C-14 sample and sub sample photograph by three independent and blinded textile experts. Second, the percent calculation was obtained using the estimates of these textile experts. Third, the radiocarbon date was calculated using the percentage of observed 16th Century versus 1st Century weave types appearing in the sample.

The radiocarbon calculations were derived using the following mathematical calculations and in consideration of the following scenarios. “Scenario A” represents the authors’ original proposal while “Scenario B” represents the counter-claim asserted by Dr. Gove.

Scenario A. What % cal AD 1500 + % cal AD 75 radiocarbon would be required to derive an average age of cal AD 1210?

Scenario B. What % cal AD 1500 + % cal AD 75 radiocarbon would be required to derive an average age of cal AD 665?

The calculation of this would be as follows:

1) The measured Conventional BP equivalent to cal AD 1500 is ~ 360 BP.

The measured Conventional BP equivalent to cal AD 75 is ~ 1940 BP.

The measured Conventional BP equivalent to cal AD 1210 is ~ 840 BP.

The measured Conventional BP equivalent to cal AD 665 is ~ 1340 BP.

Comment: "Measured Conventional BP equivalent" refers to the radiocarbon age that would be the mean 13C/12C corrected radiocarbon age measured by the laboratory.

2). The BP dates must be converted to a fraction modern value to calculate a percent concentration:

360 BP = 0.9558 (cal AD 1500 equivalent)

1940 BP = 0.7851 (cal AD 75 equivalent)

840 BP = 0.9003 (cal AD 1210 equivalent)

1340 BP = 0.8460 (cal AD 1210 equivalent)

Comment: Given only two components, a linear relationship applies to the calculation (i.e., 50/50, 25/75, 10/90 derives a straight-line relationship). The ages can not be used because they follow a logarithmic relationship.

3). The formulas for calculation then become:

A. $0.9003 = (x)(0.9558) + (1-x)(0.7851)$

B. $0.8460 = (x)(0.9558) + (1-x)(0.7851)$

4). Solving for X (where X ~ % cal AD 1500 carbon present)

A. $X = 0.6749$ ~ 67%

B. $X = 0.3567$ ~ 36%

Therefore, as proposed in Scenario A, a sample containing ~ 67% cal AD 1500 radiocarbon and ~ 33% cal AD 75 radiocarbon should yield a calibrated date of ~ cal AD 1210. NOTE: the percent variability between these percentages and the original claim of 60/40 is within an accepted margin of 10%.

In contrast, according to Scenario B, a sample containing ~ 36% cal AD 1500 radiocarbon and ~ 64% cal AD 75 radiocarbon should yield a calibrated date of ~ cal AD 665. As Scenario B demonstrates, it appears as if Dr. Gove reversed the percentages of hypothesized 16th Century and 1st Century threads in order to obtain his 665 AD dating (calculations provided by Darden Hood of Beta Analytic, June 11, 2002).

Main Shroud deemed identical to Carbon-14 sample area:

Although the reviewers, including Evin, remarked that the main Shroud was identical to the C-14 sample area, Evin's own observations call this into question. During the audiotaped Question & Answer session at the 1989 Paris Conference (Sept. 7, 1989), Evin responded, "I quite agree that the Labs did not take the weaving techniques into

account and they did not date the threads per se. . . Thus, if the weave was rewoven with threads from modern restoration, this would be reflected in more modern results."

A comprehensive test of the "patch" hypothesis was conducted by former STURP chemist Dr. Ray Rogers to ascertain whether or not a significant difference existed between the threads found on the main Shroud and those in the Raes sample, which was adjacent to the 1988 C-14 sample area. A detailed report of Rogers' observations can be found at: www.shroud.com/pdfs/rogers2.pdf.

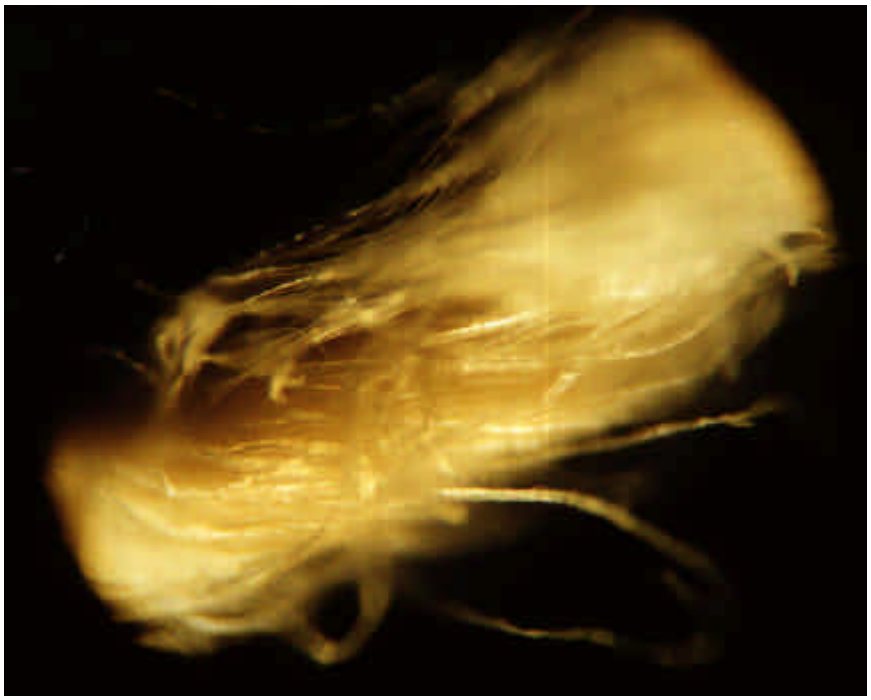

Figure 1: 100X photomicrograph taken by STURP chemist Dr. Ray Rogers demonstrating a splice in one of the threads from the Raes sample adjacent to the C-14 sample.

Rogers succinctly summarized his preliminary analysis in the November 2001 (No. 54) issue of the British Society of the Turin Shroud (BSTS) Newsletter stating, "I believe it is quite clear that the material of the Shroud is significantly different from both the Holland cloth and the Raes sample from 1973. The samples used for the dating'

of 1988 were cut from immediately above the Raes sample. **It is very unfortunate that the ^{14}C samples were not better characterized, because the evidence shows that it is highly probable that the samples were not characteristic of the Shroud and were spurious**." (6)

No splicing was observed in the Carbon-14 sample area:

While reviewing one of the threads from the Raes sample (Figure 17 in the above referenced Rogers' report), Rogers observed what appeared to be an overlap in the middle of the thread. A 100X close up of the "splice" from within the Raes sample was taken using oblique light (see Figure 1 above). Cotton was also detected in this thread.

According to the designated patch areas indicated in our original paper, the Raes sample lines up directly with what, quite possibly, is predominantly 16th Century patch. This hypothesis is also suggested by the results obtained by Rogers' microscopic analysis.

Possibility of "invisible" repairs by 16th Century weavers:

"Invisible weaving" was a popular trade in Europe during the Middle Ages. This may be due to the fact that fabric was much more precious and "non disposable" in this time period compared to today. Thus, repairs were essential. According to the Genealogical Society records of RANKS, PROFESSIONS, OCCUPATIONS AND TRADES in medieval England, the "FINE DRAWER" was "A person employed in tailoring to repair tears in the cloth. Invisible mending."(7)

More information on this medieval-type patch repair can be found on current websites that have kept the dying trade of invisible mending alive. According to one such company's website:

"Depending on the size and condition of the damaged area, and the fabric to be worked on, one of the following methods is applied: FRENCH WEAVE - Also known as the Invisible Weave, this technique is done on select fabrics with small tears, holes and burns. Individual thread strands from hidden areas, such as a cuff or inseam, are actually woven together by hand. This creates new fabric as it closes the hole and the repair is virtually indistinguishable from the surrounding fabric. Some fabrics, such as gabardine, don't always lend to completely invisible results. Anticipated results will be discussed before attempting the weaving. INWEAVING - For larger tears, and when the French weave is not practical. The weaver cuts a patch of hidden fabric and places it over the damaged area, matching the fabric's pattern. **The frayed edges are then hand woven into the material. The edges of the repair are invisible to the eye**."(8)

In the "In Weaving" technique described above, it is important to note that there is a requisite overlap and intermixing between the newer patch material and the existing textile via the integration of frayed edges into the damaged textile and vice versa. Dr. Jull noted a concern regarding the homogeneity of the sub samples stating that, "I would remind you that your hypothesis requires that the samples in each lab were combined together, whereas I know that in our lab at least, the samples were cut into smaller fragments, which were dated independently." The unavoidable interweaving required of this invisible mending technique would, most assuredly, have created heterogeneity in the C-14 sample area (see Figure 2 below). The exact ratio of patch versus original threads is not determinable by photographic analysis alone; however, as previously discussed, a well-supported estimate, based upon weave pattern changes, has been posited.

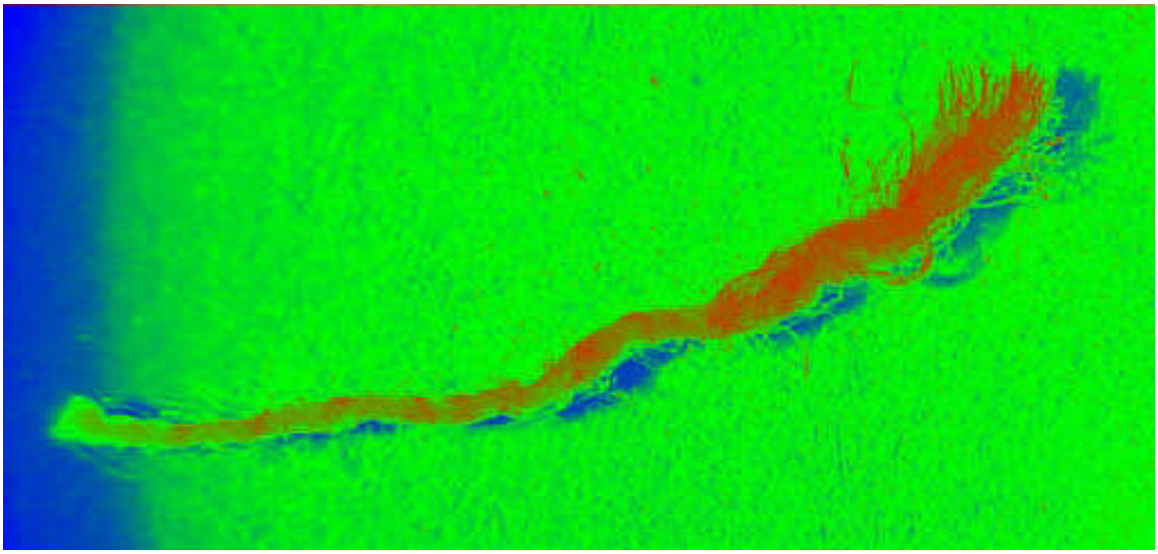

Figure 2: This color-enhanced image demonstrates the inherent intermixing of fibers in the spliced Raes thread. Notice how the red and green merges into the opposite side of the thread.

The possibility of an invisible patch being aptly rewoven into a linen textile in the 16th Century was brought to the attention of Dr. Thomas P. Campbell, Associate Curator, European Sculpture and Decorative Arts, The Metropolitan Museum of Art. Dr. Campbell, primary author of Tapestry in the Renaissance: Art and Magnificence (April 2002), wrote, "All of the major European courts had teams of skilled weavers and embroiderers who were employed in the repair of high-quality textiles. For example, at the English court there was a team attached to the Great Wardrobe, operating from the Tower of London. Much information relating to the Great Wardrobe has been published by Tout. I have a chapter on the activity relating to tapestry repairs in my unpublished Ph.D. thesis on Henry VIII's tapestry collection (Courtauld Institute, London, 1999). Much information on the repair of tapestries and textiles in the collections of the Dukes of Burgundy is published in volumes of documents published in brief in the late nineteenth and early twentieth century (for bibliography see entries in the Grove

Dictionary of Art). Similar documentation for the French royal collection has been published by Laborde, and for the Habsburg collection by Michelant. There's a pretty large bibliography in the catalogue for the current exhibition, Tapestry in the Renaissance: Art and Magnificence now at the Met.. . .Identifying sixteenth century repairs is not easy (eighteenth and nineteenth century repairs are much easier)."

When asked if he had any images of an actual invisible weave repair done in the 16th Century, Dr. Campbell responded, "No, I don't have such an image. As I said, it is very difficult to identify such repairs. They certainly must exist - **the sixteenth century weavers were magicians**, but I can't think of any documented examples." (9) (NOTE: further documentation of 16th Century invisible weaving along with historically-supported evidence is being provided in a subsequent paper by the authors).

Unauthorized dating of Raes thread

In 1982 an unauthorized Carbon-14 dating test was conducted on a single thread from the Raes sample. The experimental thread was provided by Dr. Alan Adler and given to Dr. John Heller. At the time, Adler was unaware that an agreement had been signed by STURP members not to do further testing on Shroud samples. Heller delivered the thread to the California Institute of Technology (CalTech) for dating by world-renowned mineralogist Dr. George R. Rossman. Adler informed Rossman that one end of the thread contained, what appeared to be, a “starch contaminate.” Thus, Rossman cut the thread in half and, using what Adler described as Fourier-transform ion cyclotron resonance mass spectrometry (FTMS), dated each end of the thread separately. According to the Scripps Center for Mass Spectrometry in La Jolla California, “FTMS offers two distinct advantages, high resolution and the ability to tandem mass

spectrometry experiments. First introduced in 1974 by Comisarow and Marshall, FTMS is based on the principle of a charged particle orbiting in the presence of a magnetic field. While the ions are orbiting, a radio frequency (RF) signal is used to excite them and as a result of this radio frequency excitation, the ions produce a detectable image current on the cell in which they are trapped. The time-dependent image current can then be Fourier-transformed to obtain the component frequencies of the different ions, which correspond to their m/z. Coupled to ESI and MALDI, FTMS has potential in becoming an important research tool offering high accuracy with errors as low as ±0.001%." (From http://masspec.scripps.edu/information/intro/chapter3.html#3.3.5.). According to isotope ratio expert, Dr. Vernon Anderson of Case Western Reserve University (OH), "ion cyclotron could potentially identify C-14 peaks; however, to quantify it versus $C_{12}CO_2$ is difficult."

Rossman found that the non-contaminated end of the thread dated to 200 AD while the starched end dated to 1200 AD. Although Rossman did not publish these data, Adler had confidence in his capabilities to accurately measure the age of the sample. Adler stated that Rossman is the "world's expert in it and there's no arguing with him . . .if he says these are the dates he got . . ." (10) In a personal conversation with one of the authors (Benford), Rossman confirmed that he was, indeed, the person who carried out the 1982 C-14 testing on the Raes thread provided by Adler. (11)

If there is any validity to the Rossman C-14 tests of the Raes thread, then the results support Rogers' recent findings of a spliced thread in the Raes sample as well as his observation of unilateral deposition of plant gum encrustations on only the Raes fibers. It would further support the heterogeneity of inwoven medieval restorative

threads into older, possibly 1st Century, Shroud fibers in both the Raes and the 1988 sample areas of the Shroud.

Conclusion

Although the results of Ray Rogers' research testing the hypothesis posed in the paper submitted to *Radiocarbon* was sent to the journal following the rejection of the paper, no comment or reconsideration was forthcoming from the Editor. Perhaps the reason for a lack of response has more to do with one of the reviewer's poignant observations. Jacques Evin wrote in his comments, "All people involved in the sampling and in laboratory analyses, will be very angry with these suspicions turning on so an important mistake or a misconduct."

References:

1. Damon, P.E. et al. Radiocarbon dating of the Shroud of Turin, Nature, vol. 337, no. 6208, 16 Feb 1989, pp. 611-15.

2. Marino, J. G., and Benford, M.S., Evidence for the Skewing of the C-14 Dating of the Shroud of Turin Due to Repairs. Worldwide Congress "Sindone 2000" in Orvieto, Italy, August 28, 2000 . Also available at http://www.shroud.com/pdfs/marben.pdf

3. Unpublished written communications; on file.

4. Rogers, R.N. COMMENTS ON BENFORD-MARINO HYPOTHESIS, British Society of the Turin Shroud (BSTS) Newsletter, November 2001 (No. 54).

5. Unpublished written communications; on file.

6. Rogers, R.N. COMMENTS ON BENFORD-MARINO HYPOTHESIS, British Society of the Turin Shroud (BSTS) Newsletter, November 2001 (No. 54); 33.

7. From: www.gendocs.demon.co.uk/trades.html#T

8. From: www.withoutatrace.com/dying_art.htm

9. Via email May 17, 2002; on file.

10. Audiotaped interview between Dr. Alan Adler and Mark Antonacci, December 28, 1988.

11. Personal communication between George Rossman and M. Sue Benford, June 30, 2002.