Finding the Shroud – in the 21ST Century

by *M. Sue Benford and Joseph G. Marino*

Collegamento pro Sindone Internet – December 2001

The Carbon-14 research presented in this paper was originally presented at the "Sindone 2000" conference held in Orvieto, Italy in August 2000. This paper is currently under consideration for publication by the international journal Radiocarbon whose editor, Dr. Tim Jull, was one of the members of the 1988 University of Arizona team that carbon *dated a sample from the Shroud.*

The Shroud of Turin simply will not go away. Despite the fact that in 1988 three independent AMS laboratories Carbon-14 (C-14) dated the Shroud to A.D. 1260-1390, which would be much too late for it to be the burial cloth of Jesus of Nazareth, the controversy surrounding the Shroud still rages. While critics of the Shroud's authenticity (hereafter "critics") believe that the C-14 test should have laid to rest the case for the authenticity of the Shroud, pro-Shroud supporters (hereafter "supporters") argue that something was amiss with the dating results, and they still hold that the Shroud is an authentic 1st Century burial wrapping of the historical Jesus. Since the 1988 dating of the Shroud, there have been numerous symposia, with ones also scheduled in Dallas in 2001 and France, Australia and Brazil in 2002. These symposia are always predominantly pro-Shroud.

The journal in particular, *Biblical Archaeology Review* (BAR) has published various articles over the years on the Shroud, all of which produced an avalanche of letters-to-the-editor. In the March/April 1984 issue, Robert Wild, a Jesuit priest and biblical historian, concluded that his research left him "more doubtful than ever that the Shroud of Turin is the burial cloth of Jesus Christ." In the July/August 1986 issue, crystallographer Joseph Kohlbeck and archaeologist Eugenia Nitowski presented a theory that the Shroud image, which has traces of a limestone found in Jerusalem, was formed due to moist limestone particles adhering to the cloth and heated by the high temperature of a crucified body. BAR then reported in "Remains to be Seen," Strata, July/August 1998, p. 13, that despite the C-14 results, no one has been able to account for the accuracy of the details of the crucifixion, which a medieval artist supposedly would not have been able to duplicate. This elicited objections from art historian Gary Vikan and microscopist Walter McCrone in the November/December 1998 issue. Vikan maintains that the Shroud is not, by definition, a work of art, but can be classified as part of "the long and revered tradition of sacred objects that are at once relics and icons."

McCrone insists the body and blood images are the paint pigment red ochre, in a collagen tempera medium; the blood area also contains vermilion. These were common in the Middle Ages, according to McCrone, and the style of painting is known as "grisaille," which was characterized by its faint, monochromatic image. McCrone is also well-known for supposedly debunking the "Vinland Map," a putative pre-Columbus map showing America. A group of researchers at the University of California later concluded, without being able to definitely say that the map was authentic, that McCrone's reasons for concluding that it was a 20th Century fake were basically flawed[1]. Despite the fact that the Shroud of Turin Research Project group (STURP) that studied the Shroud in 1978 disagreed with McCrone's findings, and that the University of California researchers contest his Vinland Map methodology, he steadfastly maintains that he is right in both cases. However, resolution of mysteries in science requires

more than confidence in the legitimacy of one's theories, especially when these theories are contested by other scientists. Despite the fact that the Shroud is the most intensely studied artifact in human history, further research is needed.

The validity of pollen research supporting the authenticity of the Shroud, was the focus of palynologist Vaughn Bryant in the May/June 2001 issue of BAR. Bryant believes that all of the existing pollen data from the Shroud that have been collected and studied are flawed. Dr. Alan Whanger, who was one of the authors of the book that Bryant reviewed in making his conclusions, wrote a long letter-to-the editor in the May/June 2001 issue, contesting many of Bryant's statements, and concluded with his hope that BAR will be a more open forum for continuing dialogue between varying viewpoints on the Shroud.

Recently discovered provocative new data may, in fact, change the face of Shroud research (known as *sindonology*). These data, presented in this article, are in the two most hotly debated and oft challenged aspects of sindonology, the C-14 dating and the image-formation process. Although, admittedly, much more work will need to be done, great strides have already been made.

While the critics confidently assert that the C-14 test proves that the cloth is medieval, they fail to explain how the Shroud incorporates such a plethora of authentic archaeological, biblical, anatomical, biological, chemical and physical details that simply could not have been known in that time period. For the supporters, any attempt to show that the Shroud originated in the 1st Century must first explain how three well-respected laboratories produced a date that is incompatible with an authentic 1st Century cloth.

Regarding the image-formation process, neither the critics nor supporters have been able to produce a process with supporting data that matches all of the known characteristics found on the Shroud. While critics do not feel that they have to parallel conditions in a 1st Century tomb, supporters, by definition, are required to do so. Despite the constant claims of the critics that the Shroud mystery has been solved, the simple fact of the matter is that it has not. To date, no empirical data has been presented to both sides for scientific study that matches all of the chemical and physical features of the Shroud, and, for supporters, parallels the austere conditions found in a 1st Century tomb scenario.

For these supporters, the C-14 issue must be satisfactorily addressed before positing a viable image-formation theory applicable to the 1st Century tomb. For the critics, evidence supporting a 1st Century date should necessitate reconsideration of the authenticity of the Shroud.

The Carbon-14 debate: Medieval or not

In August 2000, the authors presented a paper revealing information that demonstrates 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[2]. According to calculations performed by the world's largest AMS laboratory, Beta Analytic, during a blinded study, the observed proportion of medieval material in relationship to assumed 1st Century material, matches precisely with the findings of the AMS Labs in 1988 (see FIG. 1).

Photographs of the uncut C-14 sample, and one of the sub samples, were blindly analyzed by a European-trained weaver who reported, "there is no question that there is different material on each side of the weave pattern. It is definitely a patch!" He explained that medieval European weavers would typically try to match the original cloth and then hand-stitch the new material into the old such that it was invisible to all but the trained observer. But why do this?

Considering the C-14 sample had been excised adjacent to a previously removed area of the cloth (5 ½" x 3 ½" in size), this restoration would have been required to maintain both integrity and aesthetic consistency of the revered woven artifact (see FIG. 2). However, the patch was not an identical match; thus, even untrained observers can readily see the disparities between the two materials in the C-14 sample. Two other textile labs corroborate the weaver's observations (see FIG. 3).

Further undeniable support for this theory comes from the statistical analysis of the dates obtained by each of the three AMS Labs as they relate to the distance to the edge of the cloth. The angle revealed by "connecting the dots" matches exactly with the observable angle delineating the two disparate weave patterns in the C-14 sample (see FIG. 4).

Duplicating the Shroud image -- can it be done?

The possibility that the Shroud of Turin dated to the 1st Century, based upon the above described patching of the C-14 sample, poses an intriguing challenge to those claiming to be able to reproduce an accurate and scientifically-corresponding replication of the image itself. Logic dictates that if, in fact, the Shroud was created during the 1st Century, then only elements available at that time could have been used to manifest the haunting image of a crucified man. This challenge is exacerbated for those proposing that the Shroud image portrays the crucified Jesus of Nazareth and was rendered at some point during the post-mortem period in the burial tomb. Few would disagree with the assessment that the tomb provided a rather dismal artist's lair, "photographic" studio, or X-ray laboratory for a forger to construct the discrete and distinct full- body rendering. The only things unquestionably present would have been the tomb itself, the body of the crucified man, and the linen cloth. It is within these parameters that any successful replication process must remain in order to fully satisfy a 1st Century, post-crucifixion claim related to the image-formation process.

In keeping with these stated parameters, an experiment was setup using a linen sample provided by the late chemist and member of the STURP team, Dr. Alan Adler, who described the sample as modern but "free of dyes and starches." This sample was uniform in color throughout without any notable discolorations. Per the instructions and requirements of the experiment, agreed upon by Adler, the linen was to be exposed to nothing more than what the hypothesized 1st Century Shroud would have encountered. The first goal was to produce some discolored fibers that could be subjected to physical and chemical analyses, while a secondary goal was to attempt an actual facial image matching the man on the Shroud.

A sub-sample of linen measuring 4 x 2.5 cm was cut from the Adler linen and became the "experimental" sample. In order to more closely match the specifications of the tomb (a resonating cavity), another known resonating structure was selected for the experiment: a small-scale pyramid adhering to specifications described by Czech engineer and inventor Karel Drbal in his 1959 Patent (Republic of Czechoslovakia, Office For Patents And Inventions, Published August, 1959, # 91304). Drbal only received this patent after ten years of disclosures and submissions of experimental data to the patent office proving his claims that the pyramid, matching the geometry of Egypt's Great Pyramid, could in fact sharpen razor blades[3].

Drbal explained the results of his razor-blade research by asserting, “That such an action on the dipole-molecules of water is possible in a resonant cavity, fed with appropriate microwave energy, was proved by the scientists Born and Lertes (see: Archiv. der elektrischen Uebertragung, 1950, Heft 1, s.33-35. 'Der Born-Lertessche Drehfeldeffekt in Dipolfluessigkeiten im Gebiet der Zentimeterwellen'). It was found that the microwaves of centimetre-wavelengths

and their harmonics can produce an accelerated rotation of the water dipole-molecules, and this effect can have as a result the dehydration process - the 'driving out' of water dipole-molecules from the smallest cavities and projecting them in the open air. This is exactly the process of electromagnetic dehydration."[4] Similarly, dehydrated cellulose of the Shroud fibrils is the cause of the image according to STURP, not paint, pigments, or other substances[5].

Although not fully understood or accepted by mainstream science, some physicists do believe that the pyramid is, not only an accumulator of energies, but also a modifier of these same energies. It is recognized that any object in which energy vibrates is capable of acting as a resonating cavity. It is further speculated that this energy would affect the molecules, or crystals, of any object in the path of the beam of focused energy. Some even equate it to an invisible laser beam, having a different frequency and intensity[6].

In the first experiment, the 4 x 2.5 cm sample of linen previously described, was placed in the pyramid "tomb" that stood approximately 6 inches high. Directly on top of the linen, a miniature positive photo of the face from the Shroud was placed with face towards the linen. The apparatus was left in the dark for seven days undisturbed. No external electromagnetic or other energy sources were near the structure the entire time of the experiment. A second linen sample was exposed to 140 mrads of gamma radiation at The Ohio State University (OSU) Nuclear Reactor laboratory and served as a control. This material was never in contact with the Adler experimental sample or the pyramid structure.

Upon removing the linen from the designated "tomb," an initial visual examination revealed three areas of faint, yellow discoloration barely visible to the naked eye. No other distinctive marks were observable until approximately one month after the end of the experiment at which time an unusual light yellow, discoloration in the shape of an "infinity" symbol became apparent on the sample (see FIG. 5). In contrast, the gamma-irradiated sample was evenly discolored in a light brown hue with no pristine threads noted and no further discoloration evident after an extended period of time.

Both the experimental sample and the gamma-irradiated control were taken to the OSU Microscopic and Chemical Analysis Research Center (MARC Lab) on March 27, 2001 to determine the physical and chemical nature of the discolored fibers. The goal of the first phase of the evaluation, using a standard light microscope, aimed at answering the following questions previously denoted as key factors in evaluating a Shroud-replica: 1) does the discoloration extend beyond the surface fibers? 2) are the fibers "cemented" together? 3) does the image possess characteristics of capillarity, e.g., the image appears under crossing fibers? 4) are the colored fibers uniformly colored, e.g., can it be stated that an exposed fiber is either colored or not colored? and, 5) does rubbing the image fibers with a teasing needle reveal any adherent applied powders to be present and can any powders be seen at high magnification? Many other characteristics of the Shroud image fibers must also be met by any successful replication process (see TABLE 1 and FIGS. 6, 7, 8).

For the experimental sample, the results demonstrated that, in all areas of discoloration, only the surface fibrils were affected. For the gamma-exposed control, the discoloration was uniform throughout the entire thread. There was a "melting" of the initially-observed experimental fibers but not in the delayed-appearing fibers. No melting was observed in the gamma-treated control. In terms of capillarity, none was observed in the experimental sample and, similar to the Shroud, either the fiber was discolored or it was not. This was not the case with the gamma-exposed control wherein all threads were evenly discolored. The teasing needle did not reveal any powders or other surface additives nor did higher magnification for either of the two samples. In all factors, with the exception of the "melting" between the initially-observed

fibrils, the experimental sample results matched those of the Shroud while the gamma-irradiated sample matched only on this single variable.

The second part of the experimental analysis involved the JSM-820 scanning electron microscope (SEM). The goal of this experiment was to ascertain the chemical composition of the discolored versus the colored fibers on both the experimental sample and the control. The most notable difference between the discolored versus pristine areas on the experimental sample was in the high proportion of calcium in the discolored regions. In every instance where discoloration was found, what appeared to be crystalline calcium deposits also were present. One thought was that these were “phytoliths” (plant stones); however, the literature is noticeably silent in mentioning the production of calcium phytoliths in flax (linen). No calcium was noted anywhere on the gamma-irradiated control sample or on the pristine areas of the experimental sample (see FIGS. 9-12).

The third analysis was conducted at the OSU Chemistry Department. In this Fourier Transform Infrared Analysis (FTIR) experiment, the discolored fibers were compared to the pristine fibers on the experimental sample. Although the spectra were quite noisy and difficult to interpret, the noted discrepancies in the 3200 - 3600 cm^{-1} region may represent a dehydration effect involving the discolored fibers. This would be in keeping with other resonating cavity research citing dehydration as a major effect.

This observation of a strong calcium component within the experimental sample's discolored regions is particularly pertinent when one considers the Shroud image. According to their report entitled, "Physics and Chemistry of the Shroud of Turin," authors Schwalbe and Rogers report:

> "Morris *et al*. reported relatively uniform concentrations of calcium and strontium in all of their spectra. The large quantities of calcium (200 ± 1.0 mg cm^{-2}) were tentatively interpreted as dust accumulations, probably natural calcium carbonate, on the Shroud. Riggi similarly observed substantial quantities of calcium compounds in the samples that he vacuumed from the back-side of the cloth. Although Riggi's observation tends to support Morris' interpretation, subsequent microscopic examination of the tapes showed little or no calcium compound debris from the Shroud image surface. Heller and Adler have since postulated that the calcium and strontium were absorbed into the linen during the retting process. They draw support for this hypothesis from both an experimental demonstration of the ion-exchange process and the observed presence of iron and calcium in several other antique linen samples."[7]

However, if in fact, the calcium noted on the Shroud was due entirely to the retting process of the linen, one would expect that the image areas of the cloth and the non-image (pristine) areas would have identical calcium concentrations. Data provided to the authors by STURP member and chemist, Robert Dinegar (dated 4/3/01), from the measurements taken of the Shroud in 1978, revealed a distinct inequality in the calcium distribution on the cloth (see FIG. 13). As can be seen, the average aerial calcium density for Shroud image areas is 209 mg/cm^2 while the pristine area is almost half as much at 116 mg/cm^2. The patch area falls closer to the pristine area at 160 mg/cm^2. Although a limitation of the STURP data is that there was only one measurement of the "pristine" area on the Shroud, this dramatic divergence from the multiple image area data points suggests a possible link with our test results and, further, may indicate a connection between calcium and the surface fibril discolorations on both linen cloths.

Although the first stated goal of the replication experiment seemed promising, the second goal, producing the actual Shroud face, initially seemed unsuccessful until the discolored fibers

were observed under 310x magnification. On the tip of a single fiber, a subtle Shroud-like facial image could be seen (see FIG. 14). Was this, however, simply "cloud zoology" in which daydreamers ardently observe cloud-composed white elephants morphing into their favorite T-Rex? Or was it perhaps a "fractal" of the picture placed on the linen to represent the "body" in the tomb? The notion of a fractal is that an image is repeated time and time again in ever increasing size. Take a shore line or even a tree -- the basic shape is repeated multiple times at different scales. Can it be that the "face on the Shroud" is repeated in a fractal-like fashion on even an individual fiber, similar to in a hologram?

As most Shroud aficionados will explain, not just any face will suffice to reproduce a true Shroud image. The Shroud is known to possess "spatial encoding" qualities that permit it to be rendered with 3-D systems that convert image density (lights and darks) into vertical relief (shadows and highlights). When using one of these systems, a normal photograph does not result in a three-dimensional image but in a rather distorted jumble of "shapes." The "face" on the single fiber was sent to an optical physicist for rendering (see FIG. 15). Although not as clear and distinct as the 3-D renderings of the actual Shroud, the image appears to contain the basic facial characteristics of the man in the Shroud.

Certainly in these cases, independent verification has to be obtained; thus, an informal study was conducted with staff at OSU. Each person was independently asked to view the 2-D magnified image (approx. 600x), and to describe what they saw. Then they were asked to do the same with the 3-D rendering. Of the 17 people questioned, 14 were able to identify a face with a few claiming to see "Christ." Some saw more in the 3-D rendering while others saw more in the 2-D image. Only four people declared to see "nothing specific." Although this abbreviated test is not proof of an image, it begs the question, "Was something captured resembling the Shroud in this 21st Century test?"

Conclusion

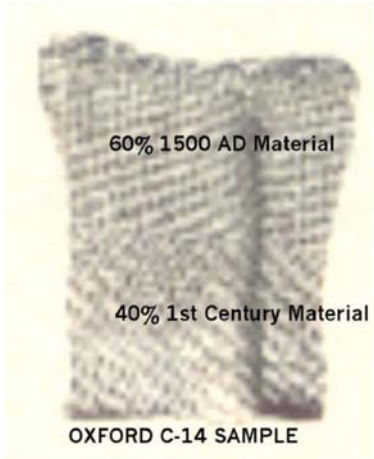
Although this reenactment of the tomb scenario produced highly-compelling Shroud-like data, one must keep in mind that there is no scientific test capable of determining whether Jesus of Nazareth was the instigator or even remotely involved in the creation of the image on the Shroud of Turin. But the idea of finding the Shroud in this, the 21st Century, is a stimulating thought and one that may, one day, forge new paths of understanding in both biblical and scientific research.

As physicist and sindonologist, Dr. Thad Trenn contends, ". . . no matter how far we succeed in unraveling the mystery of the Turin Shroud, the essential mystery remains **eternal** with a power capable of drawing every new generation into its thrall. In this respect the mysterious Turin Shroud reflects the ever-ongoing unfolding of science itself. It would be arrogant of us to expect ever to utterly dispatch either science or the eternal mystery of the Turin Shroud. That the quite unexpected and very special 'delayed image' features happened also to entail what is arguably a mini-likeness of the Holy Face itself, complete with 3-D encoding, is therefore perhaps as remarkable regarding this sense of eternal mystery as that it was formed within the infinity symbol." (via e-mail 8/2001)

As extraordinary and implausible the experimental methodologies presented may appear, one must consider what longtime Shroud research and STURP physicist concluded after years of study, ". . . scientists must be ready to overturn even their most hallowed principles if observation warrants.. . .And let us keep in mind, that, to date, no 'conventional' hypothesis has been advanced, which successfully explains the TS image."[8]

References

1. Ian Wilson, *The Blood and the Shroud,* (New York: Free Press,1998), p. 200.
2. Joseph Marino and M. Sue Benford, "Evidence for the Skewing of the C-14 Dating of the Shroud of Turin Due to Repairs," at *Worldwide Congress "Sindone 2000*," Orvieto, Italy; August 27-29, 2000.
3. Max Toth and Greg Nielsen, *Pyramid Power*, (Vermont: Destiny Books, 1974), p. 114.
4. Toth and Nielsen, *Pyramid Power*, p. 117.
5. Larry Schwalbe and Ray Rogers, "Physics and Chemistry of the Shroud of Turin: A Summary of the 1978 Investigation," in *Analytica Chimica Acta* 135 (1982), pp 3-49.
6. Toth and Nielsen, *Pyramid Power*, p. 133.
7. Larry Schwalbe and Ray Rogers, "Physics and Chemistry of the Shroud of Turin: A Summary of the 1978 Investigation," p. 17.
8. John Jackson, "An Unconventional Hypothesis to Explain All Image Characteristics Found on the Shroud Image," in *Symposium Proceedings: History, Science, Theology and the Shroud*. St. Louis. MO, June 22-23, 1991, pp. 325-344.



Oxford summary of mean radiocarbon dates
750 +/-30 = 1200 A.D. (from Nature, 1989)

Beta Analytic calculations based on 60/40 ratio
(by mass) of 450 BP (1500 A.D.) threads/ 1875 BP
(75 A.D.) threads = 1210 A.D.

Figure 1

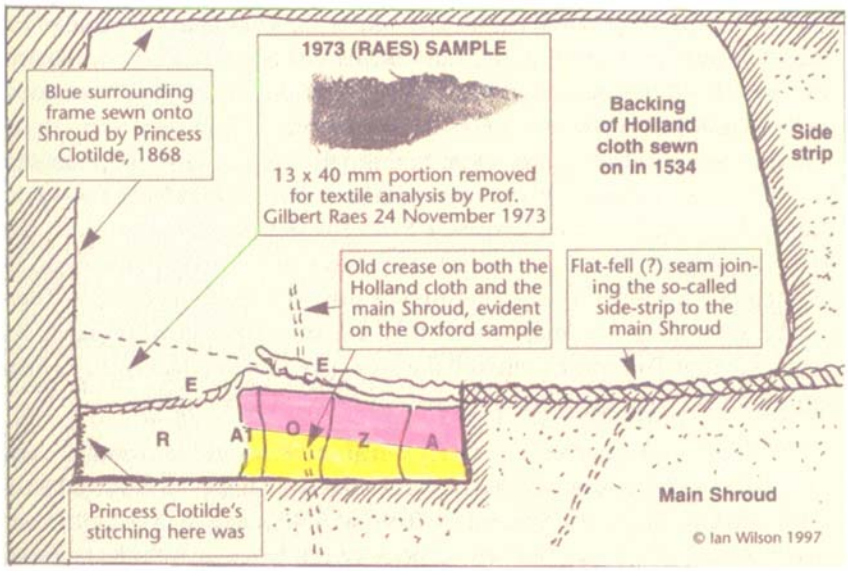
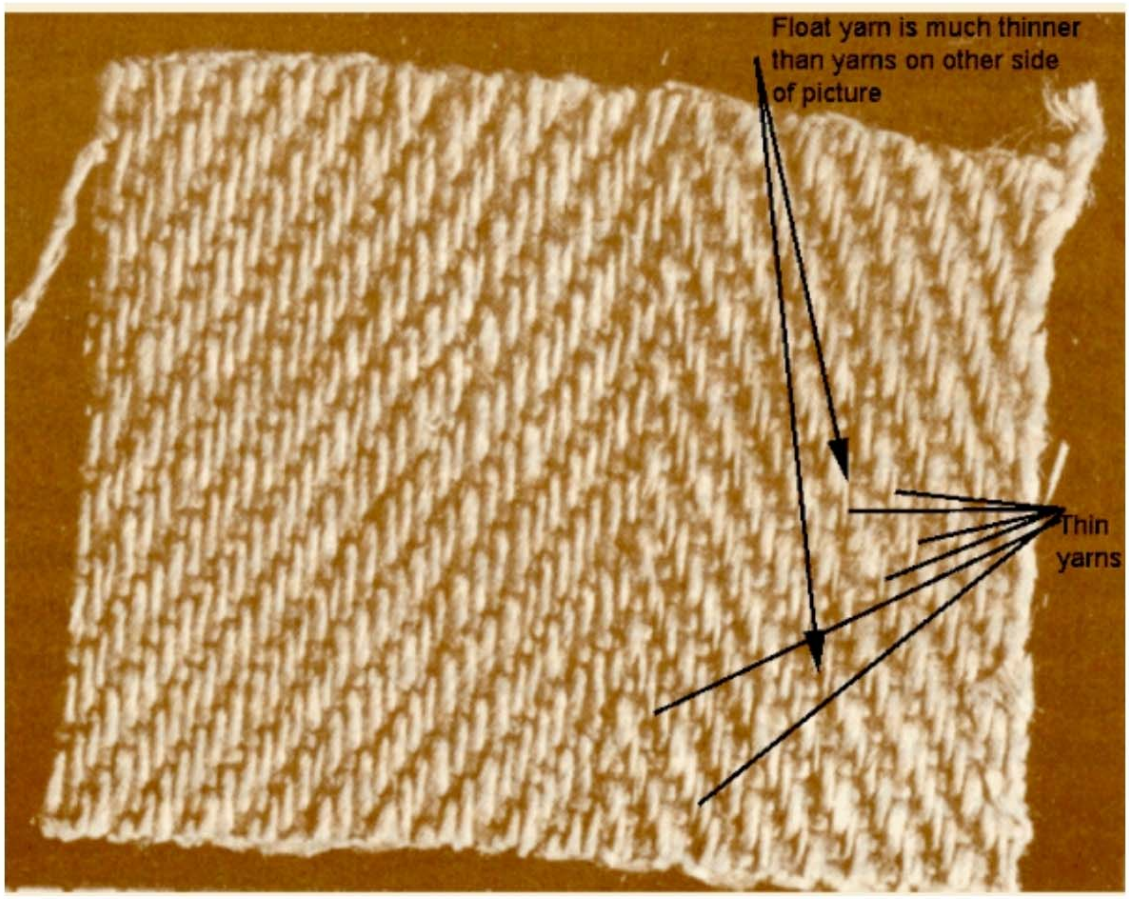


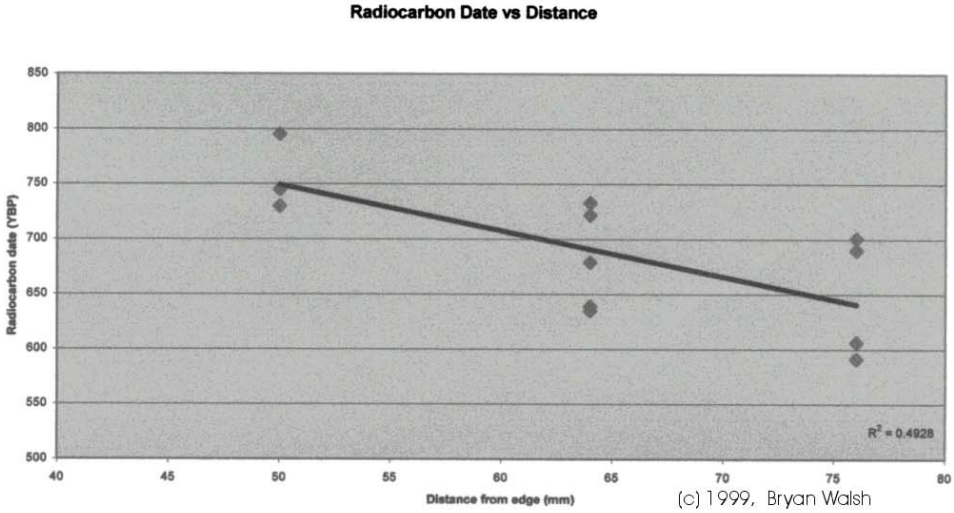
DIAGRAM OF CORNER FROM WHICH C-14 SAMPLE WAS TAKEN HIGHLIGHTED TO SHOW PROXIMITY AND DEGREE (APPROX. ½ INCH FROM SEAM) OF ATYPICAL THREADS (PINK) TO MISSING SECTION OF SHROUD

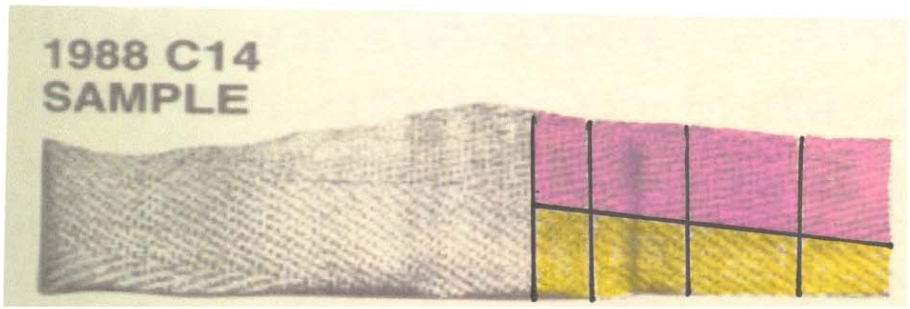
Figure 2



Weave pattern inconsistencies noted in blinded review of the Zurich C-14 sample by Albany International Research Company.

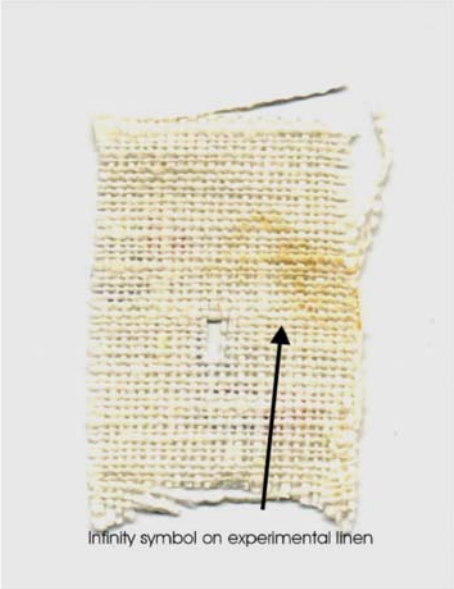
Figure 3





Illustrations showing the precise statistically-determined angular skewing of the dates corresponding with the individual laboratories with reference to the location of the samples received.

Figure 4

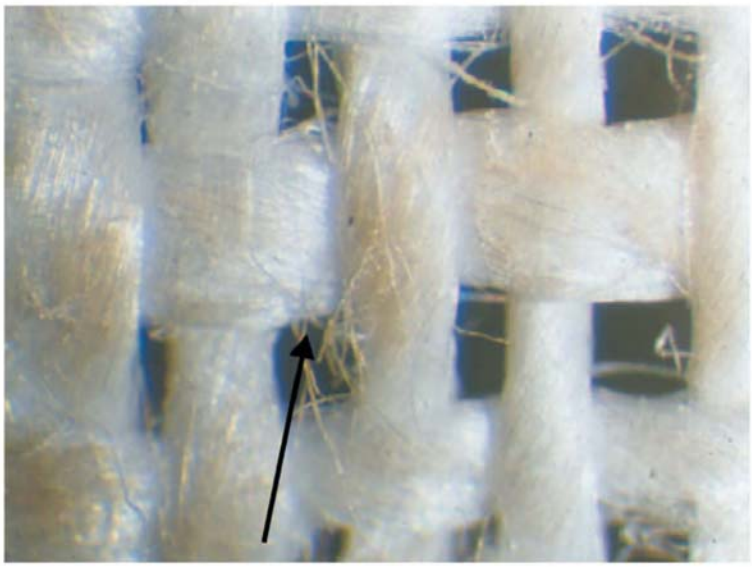


Infinity symbol on experimental linen

Figure 5

310x magnification of discolored fibers on the experimental linen. Note uniform color of fibers suggesting density of discolored fibers is responsible for the deeper hue vs. color variation.

Figure 6



This slide of the discolored fibers on the experimental linen sample demonstrates a partially-exposed fiber. As with the Shroud, the individual image pixels have very sharp boundaries at their ends across the diameter of the fibers. When seen at a magnification of 310x power, the boundary between the discolored pixel and the clear fiber demonstrates a sharp change. There is no gradual edge as expected from a shadow mask or external light source. (May 10, 2001)

Figure 7

310x magnification of discolored fibers on experimental linen sample. Note the color in the tips that appears to stop and start in the upper crown of the fiber.

Figure 8

Project 1

Spectrum processing :

Peaks possibly omitted : 0.775, 2.656 keV

Processing option : All elements analysed (Normalised)

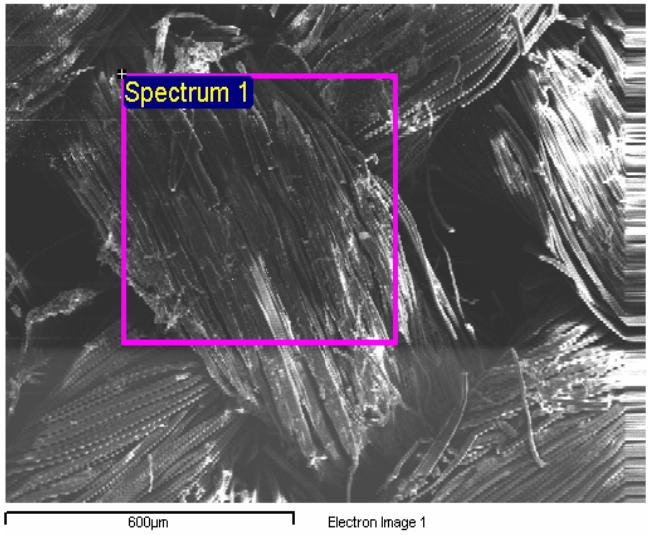
Number of iterations = 4

Standard :

C K CaCO3 1-Jun-1999 12:00 AM

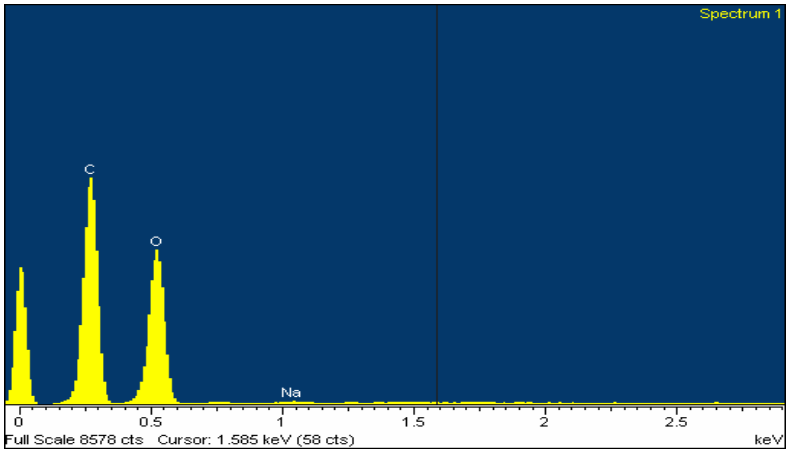
O K SiO2 1-Jun-1999 12:00 AM

Na K Albite 1-Jun-1999 12:00 AM



Element	App Conc.	Intensity Corrn.	Weight%	Weight% Sigma	Atomic%
O K	18.29	0.5500	54.78	0.16	47.67
C K	30.29	1.1067	45.05	0.16	52.23
Na K	0.07	0.6605	0.17	0.02	0.10
Totals			100.00		

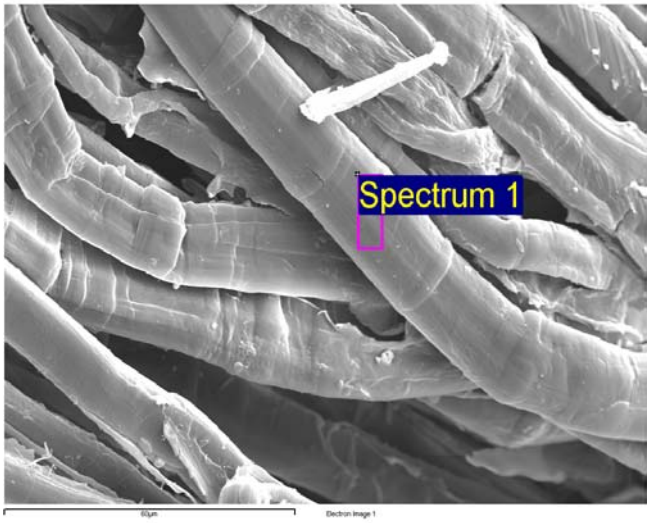
Comments: Gamma irradiated control sample showed no sign of calcium



Project 1

Spectrum processing :

Peak possibly omitted : 1.080 keV



Processing option : All elements analysed (Normalised)

Number of iterations = 4

Standard :

C K CaCO3 1-Jun-1999 12:00 AM

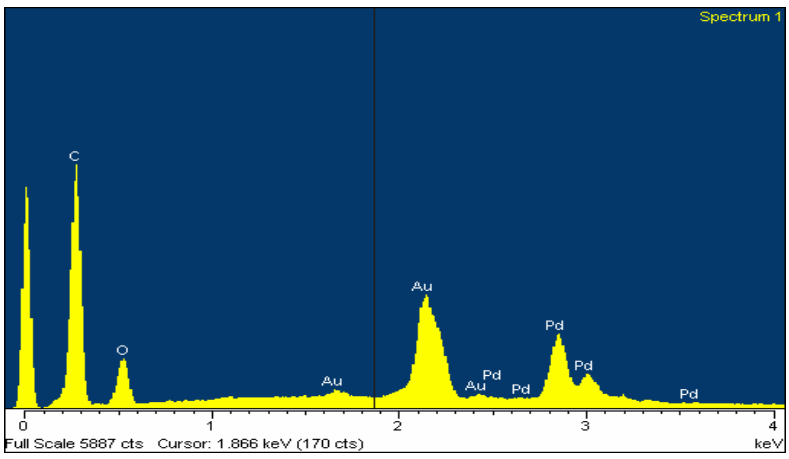
O K SiO2 1-Jun-1999 12:00 AM

Pd L Pd 1-Jun-1999 12:00 AM

Au M Au 1-Jun-1999 12:00 AM

Element	App Conc.	Intensity Corrn.	Weight%	Weight% Sigma	Atomic%
C K	22.05	1.0317	50.40	0.17	72.37
O K	3.70	0.3843	22.69	0.16	24.45
Au M	5.97	0.8822	15.95	0.12	1.40
Pd L	3.52	0.7578	10.96	0.13	1.78
Totals			100.00		

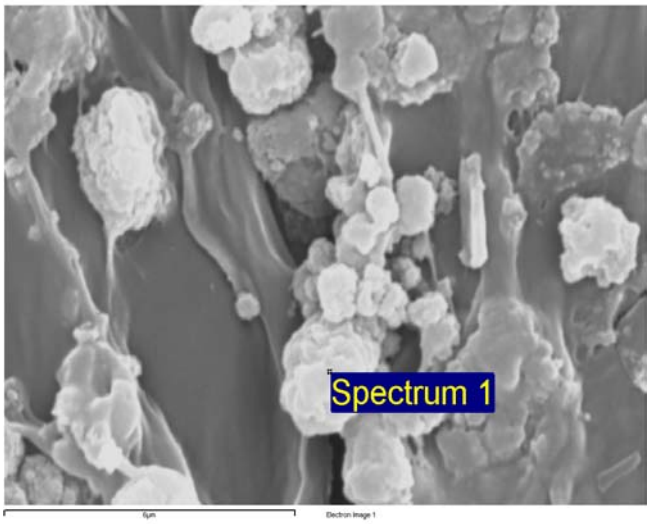
Comment: Pristine areas of experimental sample showed no sign of calcium.



Project 1

Spectrum processing :

Peak possibly omitted : 0.510 keV



Processing option : All elements analysed (Normalised)

Number of iterations = 2

Standard :

C K CaCO3 1-Jun-1999 12:00 AM

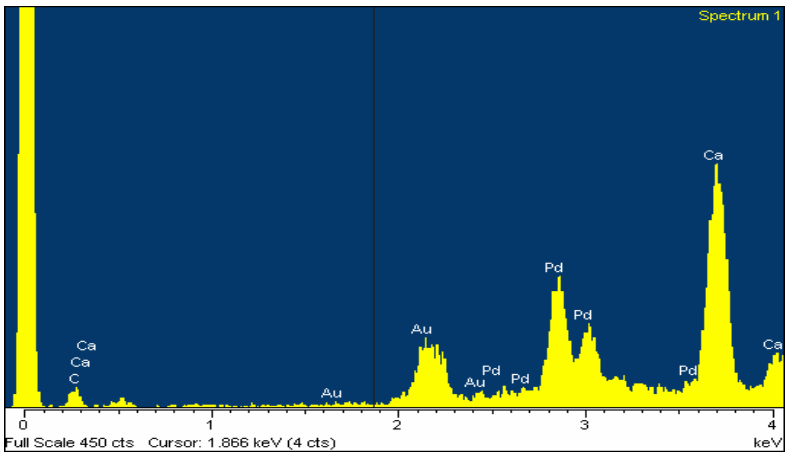
Ca K Wollastonite 1-Jun-1999 12:00 AM

Pd L Pd 1-Jun-1999 12:00 AM

Au M Au 1-Jun-1999 12:00 AM

Element	App Conc.	Intensity Corrn.	Weight%	Weight% Sigma	Atomic%
Ca K	0.61	0.8746	40.61	0.03	43.48
Pd L	0.45	0.8284	31.57	0.04	12.73
Au M	0.25	0.8910	16.57	0.03	3.61
C K	0.18	0.9543	11.25	0.02	40.18
Totals			100.00		

Comment: Fibers in the discolored regions showed large amounts of calcium deposits



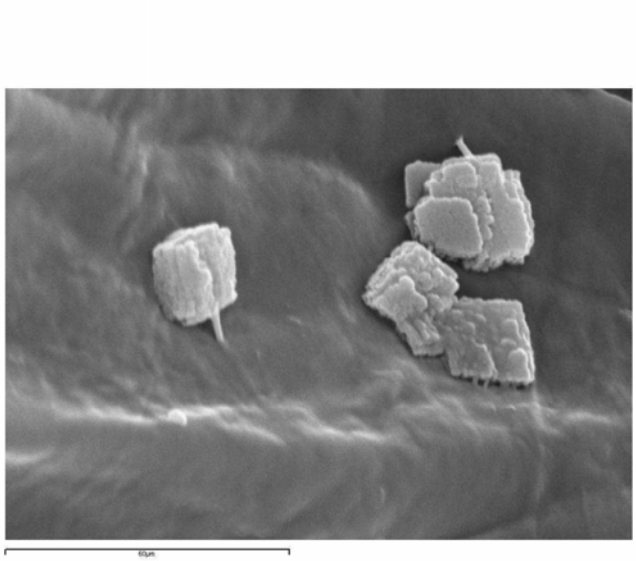
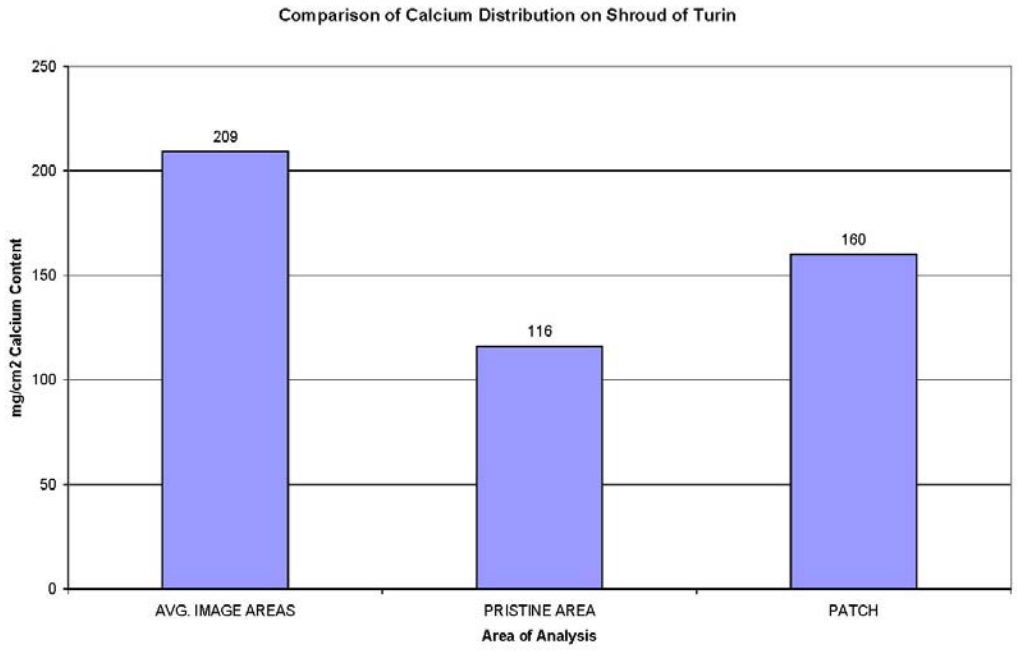


Figure 12

FIGURE 13



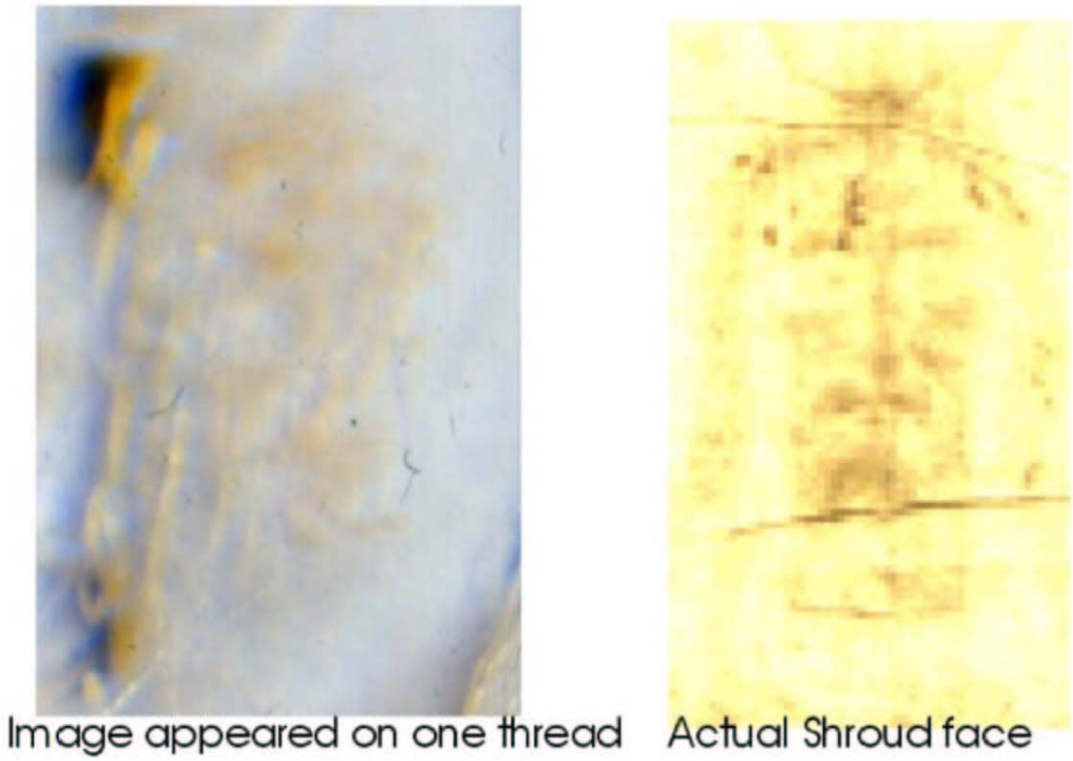


Figure 14

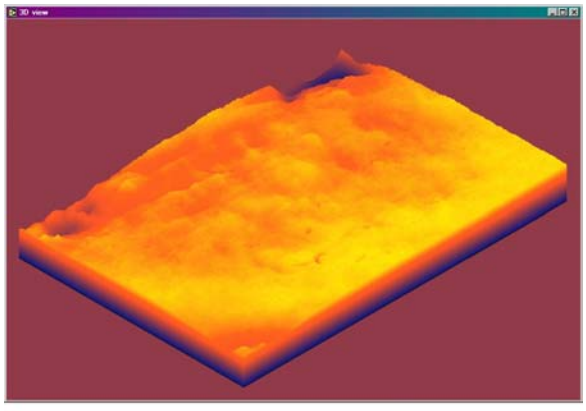


Figure 15

TABLE 1: COMPARISON OF CHARACTERISTICS BETWEEN SHROUD, EXPERIMENTAL SAMPLE, AND GAMMA IRRADIATED CONTROL LINEN

Characteristics examined	Turin Shroud	Experimental Sample	Gamma Irradiated Control
Does discoloration extend beyond surface fibrils?	**NO**	**NO**	YES
Are the fibers "cemented" together?	**NO**	**NO**	NO
Does the image possess characteristics of capillarity?	**NO**	**NO**	YES
Are the colored fibers uniformly colored?	**YES**	**YES**	YES
Are any powders noted on surface of discolored fibers?	**NO**	**NO**	NO
Is calcium noted in discolored regions?	**YES**	**YES**	NO
Is calcium noted in pristine regions?	**MINIMAL**	**NONE NOTED**	N/A ALL DISCOLORED
Does FTIR analysis indicated spectral differences between discolored and pristine areas?	**YES**	**YES**	N/A
The image is a single color, a yellowing or discoloring of individual fibers	**YES**	**YES**	YES
Chemical changes in discolored regions resulting from dehydration and oxidation	**YES**	**YES**	N/A
The individual discolored pixels have very sharp boundaries at their ends	**YES**	**YES**	NO

Characteristics examined	Turin Shroud	Experimental Sample	Gamma Irradiated Control
At the boundary between the image pixel and the clear fiber, there is a sharp change. There is no gradual edge.	**YES**	**YES**	NO
There is no sideways or angled discolored fiber formation	**YES**	**YES**	N/A
Lighter and darker shades of straw-yellow is due to the number of pixels or the relative length of pixels in any given area of the cloth	**YES**	**YES**	N/A
Discolored areas can be best described as gravitationally collimated	**YES**	**YES**	N/A
Discoloration appeared without application of known chemicals, radiation or light sources	MAYBE	YES	NO
Discoloration occurred without direct human intervention	MAYBE	YES	NO
A recognizable image appears in the discolored fibers	**YES**	**YES**	NO
Image contains spatial encoding capable of 3-D rendering	**YES**	**YES**	N/A
Discoloration appeared only when in direct contact with a "witness"	**YES**	**YES**	NO
Energetic particles have been detected in proximity to discoloration event	NO	MAYBE	YES