SOME DETAILS ABOUT THE STURP QUAD MOSAIC IMAGES

Author's Note: This article was originally written in 2003 and was made available only to the online Shroud Science Group. Ray Rogers had pointed out in a posting to the group that this image is another important piece of scientific evidence supporting the belief that the area sampled for the C14 dating in 1988 was anomalous. I wrote the article with the assistance of Jean Lorre, original STURP imaging team member from the Jet Propulsion Laboratory, who had performed the image processing. As the topic of the article is quite important to ongoing Shroud studies, I have decided to update it and make it available to the general public. The only revisions I made were those relevant to the untimely passing of Jean Lorre.

I must first note that, as far as I can recall, much of the image processing done on Shroud photographs by (the late) **Don Lynn** and **Jean Lorre**[1] at the Jet Propulsion Laboratories in the late 1970's and early 1980's was never completely analyzed. Don and Jean were only able to use JPL's facilities in their "spare" time, and the various ongoing NASA projects of the day (Voyager, Viking, Mariner and Galileo) limited both their own time and their access to the NASA computers. Consequently, very little of this work was included in STURP's published papers and as a result, there are no references to these images in any of the journals I could find. Of course, Don and Jean were the best qualified to describe what they did, and I was fortunate to recently reconnect with Jean again after more than twenty years. He was kind enough to review this article, provide detailed new information on the image processing he performed (included below) and correct some of my earlier assumptions. Since incorporating Jean's input, I have made the necessary corrections and updated those areas where my original comments were inaccurate.

To write this article, I went back to the original STURP test plan[2] to review the original description of this experiment. Using that as a reference, I have first provided some additional details about the equipment, film and techniques that were used. I then provide Jean's description of the image processing technique and give my opinion on the data shown in the photograph.

The formal name for this portion of the Photography Test Plan was "Spectrally-resolved Quad-Mosaic Photography." It called for photographing the Shroud so that each image would cover a 4' x 4' region of the cloth (hence the term "quad"mosaic). One set of photographs was made through B/G/R (Blue/Green/Red) Color Separation filters (over the lens), another through narrow band ~ 100 A° (nanometer) filters spaced over the visible spectrum and a final set was made with no filters at all. Vern Miller used a motorized Hasselblad ELM medium format camera fitted with a Carl Zeiss 150mm f4 Sonnar lens and 70mm Kodak SO115 panchromatic black and white film. The film was an ISO (ASA) 100, ultra high resolution (300 line pairs/mm), ultra fine grain film that allowed enlargements to be made up to 100X without appreciable visible film grain.

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[1] Don Lynn died on October 14, 2000. Jean Lorre died on December 14, 2005. Vern Miller died on April 10, 2009.

[2] "Operations Test Plan for Investigating the Shroud of Turin by Electromagnetic Radiation at Varying Wavelengths," Shroud of Turin Research Project, Inc., 1978

Kodak custom coated the emulsion onto a 70mm motion picture film base specifically at STURP's request so we could use the Hasselblad long roll film back that allowed for 70 exposures per roll. The actual imaging area for each frame of film was 2¼ square inches. (Interesting side note: NASA chose these same cameras for use on the Apollo lunar missions and ultimately left six specially-modified Hasselblad ELM camera bodies on the moon because of the space and weight limitations of the returning spacecraft). The film was furnished in long rolls and was hand loaded (using a 70mm bulk loader) into the special cartridges used by the Hasselblad film magazines. The "SO" in the film name stands for "special order," since the film was not available commercially at that point in time. However, several years later Kodak did release the film commercially under the trade name Technical Estar Pan.

The lighting was provided by two Norman 200 watt-second professional photographic strobe heads. These used xenon flash tubes (high output, short duration) with a color temperature output of approximately 5000 K (daylight). Norman incorporated glass or plastic covers over the reflectors to help filter and reduce excessive UV output. I originally believed that the lighting had been adjusted to ensure uniform illumination, but I was not directly involved in making the photographs myself and apparently, that was not the case. Jean dealt with the illumination issue in the image processing (described below).

We are primarily concerned here with the B/G/R Color Separation set. In this technique, three separate black and white film frames are exposed for each area of the Shroud. Each exposure is made onto a separate frame of film using a different color separation filter over the lens (the blue filter used was a Wratten #47B). These filters pass or transmit only their respective portion of the visible spectrum so that only the blue, green or red portions of the visible spectrum reflected off the Shroud are recorded onto the panchromatic film. These three separate black and white images can then be used either individually, based on the portion of the spectrum they recorded, or recombined to recreate a full color image. This "Additive Color" technique is actually the basis of many color photographic processes and materials, including Kodachrome film.

The first photograph below is a cropped portion of what originally was called the Blue Quad Mosaic. I initially believed this image was processed from the exposure made through the blue color separation filter only (and hence the name "blue" quad mosaic). However, Jean tells me that all three B/G/R exposures were used to create this image and provided this response when I asked him why the photographs were labeled "blue:"

> "Good question. I don't know why, probably just confusion in communications. Don probably didn't recall the processing steps we went through."

The original negatives were scanned with a scanning microdensitometer using a 50 micron spot size at 28 micron spacing. At this point, I am including Jean Lorre's personal description of his image processing techniques. It is important to note that at the time this was written, Lorre was not at all aware of the Rogers or Benford/Marino theories.

> "The images were originally r,g,b color separations as you describe. There was a strong illumination brightness falloff from the center. This was eliminated by dividing each image by a flat field. The flat field was composed of the sums of all the images added

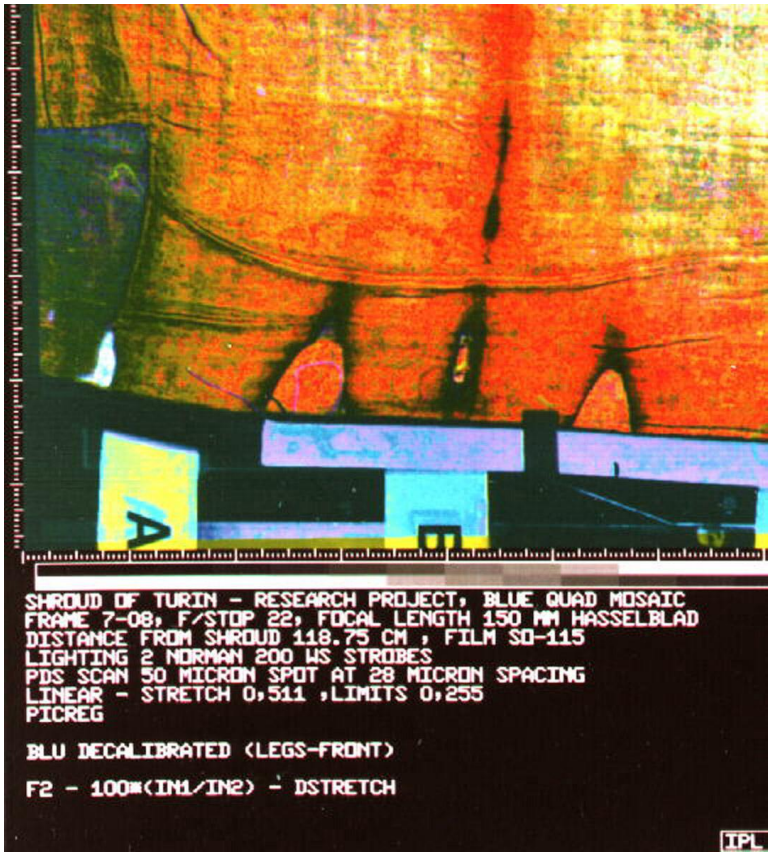
together, flipped left to right and top to bottom, in all combinations in order to generate a featureless illumination model. After flat field correction the images were flat and, when viewed in color, were gray with slight color variations. As you recall the overall shroud was very pastel with only hints of variation from tan.

"We wanted to enhance the color to reveal subtle colors which might betray spatial variations in **chemical composition** (emphasis mine). Since the r,g,b images were highly correlated, contrast stretching only made them different contrasts of gray. So that was no help. We resorted to principle component analysis, also known as Karhunen Loeve analysis. Here one computes the covariance matrix and from this solves an eigenvalue problem which results in eigenvectors. The eigenvectors provide a rotation matrix which rotates each color image in r,g,b space to create images called principal component (PC) images. We then subjected each PC image to a gaussian stretch so it's histogram was gaussian. Then we inverse rotated the stretched PC images into r,g,b space once again. Now the r,g,b images were permanently decorrelated but retained their general colors. These are the images you have. What we essentially did was to spread the colors out from gray to fill all the available color space in a smooth way, preserving the original color balance. Another way to look at it is we greatly exaggerated the color saturations while preserving the original hues and intensities.

"**These color images should be interpreted as chemical composition maps** (emphasis mine). We don't know from the images what these chemicals are, only that they are not the same everywhere. The same color in two locations indicates a likelihood that the same chemistry exists at both locations. Beware that these are radiometrically uncalibrated cameras. One must be cautious in over interpreting them since we had to struggle to get them into a form we could enhance, a process requiring some creativity. So that's the story. Your web site is a wonderful instrument to assist in binding these loose ends together. Please keep in touch."[3]

I originally believed that the various colors indicated differences in spectral reflectivity. However, Jean points out that these actually indicate differences in chemical composition. So the similarities in the patch in the lower left corner and the areas immediately adjoining it, actually indicate those areas are similar in chemical composition and different from other areas of the Shroud. Of course, we would expect the patches to be different because we know they are made of different material than the rest of the Shroud. However, notice that the area adjoining the patch (where the c14 sample was taken from, and ostensibly part of the actual Shroud) is also mostly the same color of green. This is further convincing, supportive, scientific evidence that this area is inherently different in composition than the rest of the Shroud. The fact that the white light photographs show a different coloration in this area, along with the UV fluorescence photography images which clearly show different fluorescence properties in exactly the same areas, coupled with Ray Rogers' detailed chemical and microscopic analyses and the Marino-Benford textile evidence that has been presented over the last few years, all make me believe that the 1988 c14 samples of the Shroud were taken from an anomalous portion of the cloth.

[3] Personal correspondence with Jean Lorre December 2, 2003



Top: Shroud Quad Mosaic, Original B&W Photographs © 1978 Vernon Miller, Enhancement © 1980 Jean Lorre Collection, STERA, Inc. Bottom: STURP team members (l to r) Vernon Miller, Samuel Pellicori and Don Devan setting up the Hasselblad camera system and Norman 200 strobes on the custom built camera support system for the 1978 photographic experiments. © 1978 Barrie M. Schwortz Collection, STERA, Inc.