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Full length Research Paper

Particle radiation from the body could explain the Shroud's images and its carbon dating

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This paper highlights some of the main reasons why radiation caused the body images on the Shroud of Turin; why the source of this radiation was the body wrapped within it; that the radiation appears to be particle radiation; and that if particle radiation came from the body of the man in the Shroud, it could account for or explain all of the primary and secondary body image features, the excellent condition of the cloth, its back side imaging, its possible coin and flower images, and the still red color of its centuries old blood marks. Particle radiation could also explain the Shroud's 1988 radiocarbon dating.

Key words: Turin Shroud, radiocarbon, neutrons, protons.

INTRODUCTION

The following is a list of 32 unique or unusual features that are found on the Shroud's body images or fibers:

- lack of fading
- lack of foreign materials or particulates
- straw yellow coloration
- only topmost superficial fibers of threads encoded
- individual fibers encoded
- fibers colored 360° around circumference
- only outer layers of individually encoded fibers are colored
- no coloration inside of fiber
- fibers colored with similar intensity
- oxidation and dehydration of fibers
- containing conjugated carbonyls (double-bonded carbon atoms formed after single-bonded atoms within linen fibers broke apart)
- developed over time
- accelerated aging of the body image
- stability to water and heating
- insolubility to acids, redox and solvents
- gross mechanical properties of linen intact
- microscopically corroded appearance of fibers
- lower tensile strength of fibers
- reduction of the cloth's fluorescence
- lack of residue
- highly attenuating or absorbing agent
- agent operated over skin, hair (coins and flowers)
- non-diffuse image with sharp boundaries
- equal intensity for frontal and dorsal images
- lack of two-dimensional directionality
- negative images with left/right and light/dark reversals which develop into
- highly resolved, photographic quality images
- without any magnification
- with skeletal and dental features
- three-dimensionality
- encoded through the space between the body and the cloth
- in a straight-line vertical direction

(Jumper et al., 1984; Heller and Adler, 1981; Schwalbe and Rogers, 1982; Jackson et al., 1984, 1982, 1977; Avis et al., 1982; Tamburelli, 1981, 1982, 1985; Jackson, 1989; Ercoline et al., 1982; DiLazzaro et al., 2010; Jackson et al., 1988; Fanti et al., 2010a,b; Heller, 1983).

RADIATION FROM THE BODY

The above features were all gradually observed by scientists when they started studying the Shroud 30 to 40 years ago. Some of these were first observed by comparing the Shroud's body images to its light scorches, then by making light scorches on linen in the laboratory,

by various experiments, and by detailed examination of the Shroud and its samples.

All of these features can be accounted for by radiation and only radiation will account for all of them. Throughout this paper, the term radiation refers to non-thermal or low temperature radiation. Observing the comments of the late Dr. Luigi Gonella, the former Scientific Advisor to Cardinal Ballestrero, regarding two of these features: “An agent acting at a distance with decreasing intensity is, almost by definition, radiation. The limitation of the cloth darkening to the outermost surface pointed to a non-penetrating, non-diffusing agent, like radiant energy.” (Gonella, 1987)

Radiation seems to be the only method capable of encoding other features on the Shroud. For example, only vertical beams of light or radiation illustrate how the Shroud’s body image was encoded through space in a straight-line direction from the body to the cloth. As Dr. Gonella explained, “Whatever the mechanism might be, it must be such to yield effects as if it were a burst of collimated [parallel beams of] radiant energy.” (Gonella, 1987)

Because of page limitations, only some of the reasons why radiation caused or contributed to the Shroud’s body images and why the body was the source of the radiation are highlighted in this paper. However, the experiments of Dr. Sebastiano Rodante, Prof. Nicholas Allen and the Shroud of Turin Research Project (STURP), in which radiation emitted or reflected from a body model also indicate many of these points (Antonacci, 2000). This paper draws from and expands the Historically Consistent Method (Antonacci, 2000) which in turn was greatly influenced by the models and experiments of Dr. John Jackson (Jackson, 1990, 1991), Dr. Jean-Baptiste Rinaudo (Rinaudo, 1998, 1996, 1994, 1992), Mario Moroni (Moroni et al., 1998, 1999) and their associates.

The nearly unanimous conclusion of pathologists, physicians and anatomists who studied the Shroud since the beginning of the 20th century is that the Shroud wrapped a dead human body. In summary, the arterial and venous blood flows on the head; the different types of bruises and swelling identified on the face; the flow of watery fluid from the pleural cavity and of blood from the right auricle, which fills with blood on death; the photographically revealed abrasions at the knees, nose and across the shoulder blades; the abnormally expanded rib cage indicating asphyxia; the enlarged pectoral or chest muscles drawn in toward the collarbone and arms; the contraction of the thumbs from an injury to the median nerve; the unusual signs of traumatic shock; the numerous signs of rigor mortis; the post-mortem bleeding; the microscopically precise, invisible reactions around the more than 100 scourge marks throughout the body; the coagulated blood stains with serum surrounding borders and clot retraction rings that occur with actual wounds and blood flows, found throughout the front and back of the body, and revealed only by modern scientific technology; and the identification of human hemoglobin, human albumin, human whole blood serum, human immunoglobins, and human DNA from the man’s blood marks — are just some of the signs that the Shroud wrapped the body of a dead human male (Antonacci, 2000).

Because of length restrictions, this paper cannot begin to cover all the evidence or research in support of its central thesis; however, it will provide further basic reasons how and why radiation from this body caused the itemized features on the Shroud.

The Shroud’s frontal and dorsal body images are encoded with the same amount of intensity, independent of any pressure or weight from the body (Jackson et al., 1984). The bottom part of the cloth (containing the dorsal image) would have born all the weight of the man’s supine body (Figure 1), yet the dorsal image is not encoded with a greater amount of intensity than the frontal image (Figure 2). Radiation coming from the body would not only explain this feature, but also the left/right and light/dark reversals found on the cloth’s frontal and dorsal body images.

Beginning with Dr. Giles Carter (Carter, 1984, 1999) and continuing with Dr. John Jackson (Jackson, 1990, 1991), Dr. August Accetta (Accetta, 1999, 2000), Dr. Alan Whanger (Whanger and Whanger, 1998) and Professor of Anatomy Michael Blunt (Wilson, 1988), skeletal features such as finger bones, bones extending over the palm, part of the skull at the forehead, the left thumb, parts of the backbone and even teeth have been indicated on the man in the Shroud. Each of these scientists, physicians and long time experts on the Shroud has concluded that only radiation could have encoded such internal features onto the cloth. And, while these experts may vary somewhat in the particular form of radiation involved, all have concluded that only radiation projected from the body could have encoded the man’s skeletal and dental features.

All these internal skeletal (and dental) features lie near the surfaces on the front and back of the supine body of the man wrapped in the Shroud. Like all the Shroud’s body image features, they are encoded correctly, and none were visible for hundreds of years - until the development of modern technology.

Dr. Carter, who first suggested these features, thought they indicated not only that radiation came from the body, but that it resembled or had qualities analogous to X rays (Carter, 1984, 1999).

Interestingly, enlargement and diffusion of the body’s bones, ligaments, and skin normally occurs when X-rays are made. That is because the rays leave an external tube before hitting a part of a person’s body and being recorded on film. The degrees of magnification and diffusion vary with the degrees of distance. The shorter the distance between the source of X-rays and the body, the greater are the degrees of enlargement and diffusion. For the short distances that necessarily existed between the Shroud cloth and the underlying body, extensive

Figure 1. Illustration of the man's weight on the dorsal side of cloth (16th century painting by della Rovere).

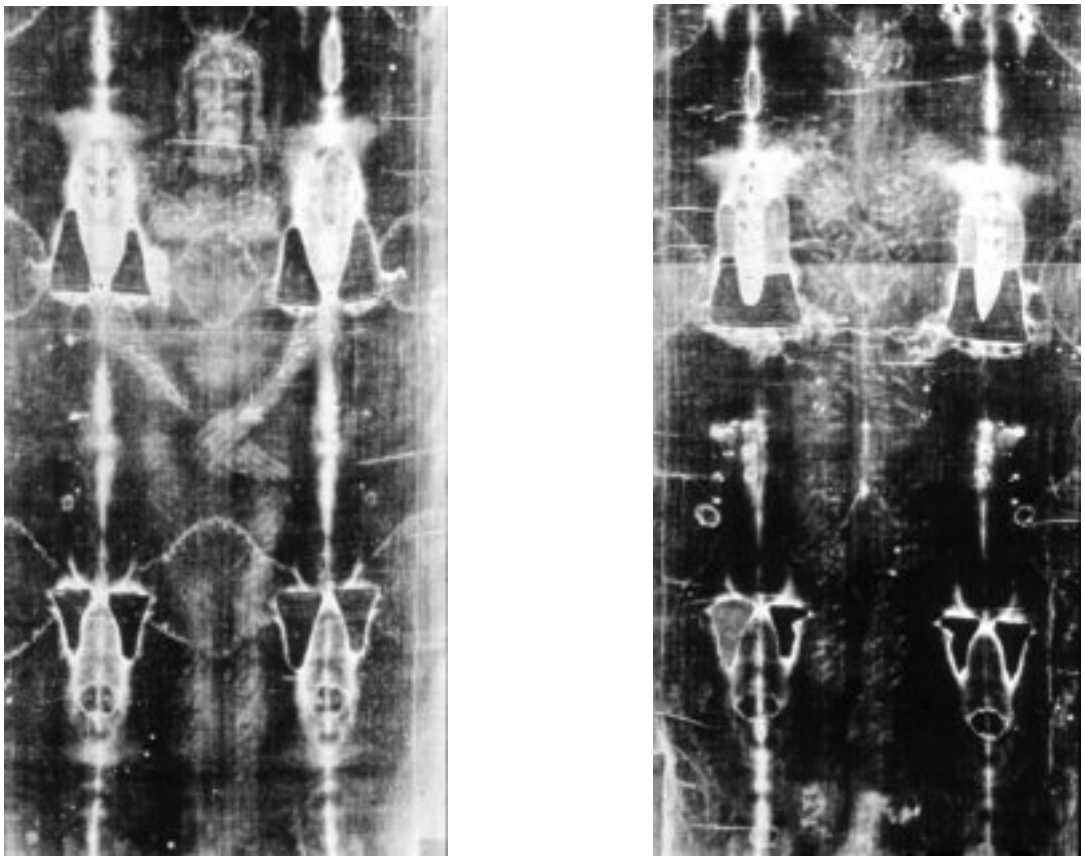

Figure 2. Negative, contrast-enhanced frontal and dorsal images on Shroud (Copyright, 1978, Vernon Miller).

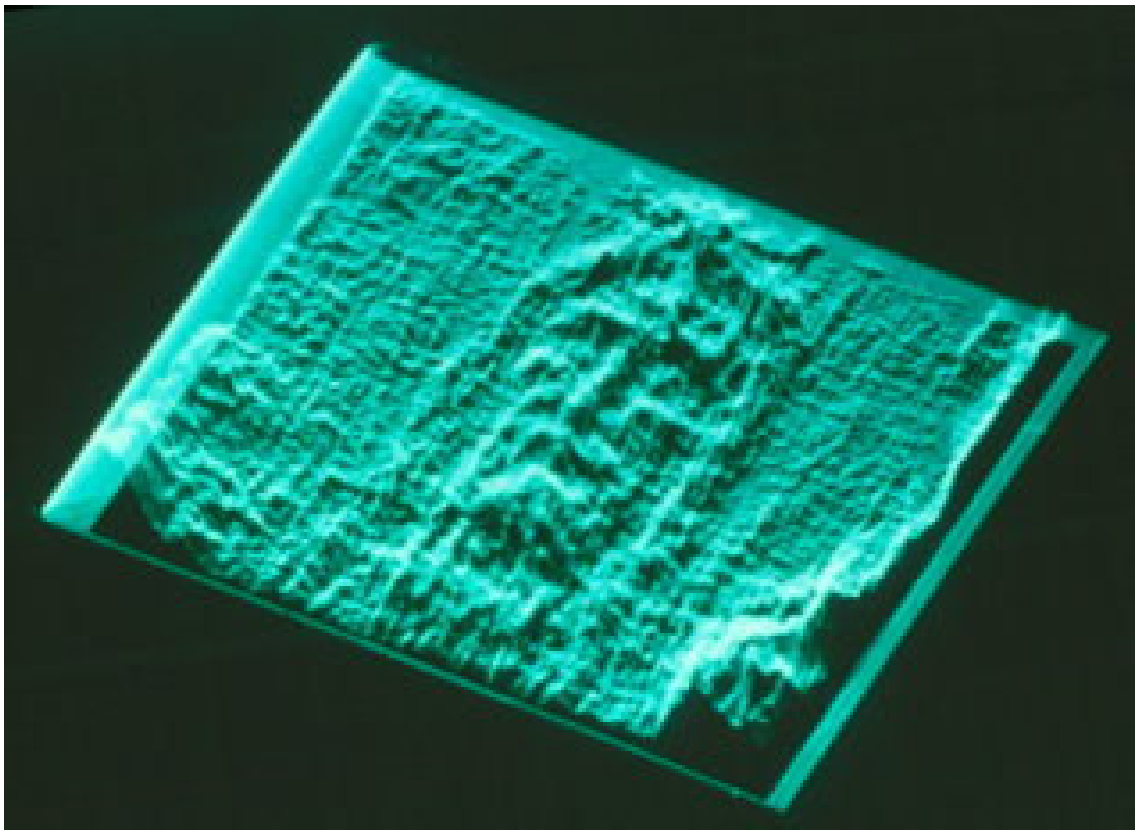

Figure 3. Three-dimensional VP8 image of face (Copyright, 1978, Vernon Miller).

enlargement and diffusion would have clearly been present if the source of radiation came from outside the body. However, the Shroud's body images are highly resolved without any enlargements. Both attributes indicate that the source of the light came from the body itself.

As in photography, if the light came from any source outside of the body, objects that were illuminated by the light in its path from its source to the film would have been recorded on the film or images. In the case of the Shroud, the film is clearly the inside part of the cloth that wrapped the body. Significantly, neither the outside or inside of the tomb, nor the outside or inside of the cloth are found on the Shroud's distinctive images. Only the front and back sides of the man's body are seen on the Shroud's extraordinary images. This means that the source of the light does not originate outside of the body, but with the body itself.

The Shroud's truly proportional, full-length, and three-dimensional frontal body image was first demonstrated with a VP8 image analyzer indicating a direct correlation between the lightness and darkness at each point on the Shroud's body image with their respective distances from the underlying body as shown in Figure 3 (Jackson et al., 1984, 1982, 1977; Avis et al., 1982; Tamburelli, 1981, 1982, 1985). Since each point of distance information on the frontal body image was received by the cloth and is contained on the cloth - they could only have come from the underlying body.

When the two men at each end of the body in Figure 4 let go of the cloth, the top of it will conform roughly to the contours of the underlying body. Yet, regardless whether the Shroud was sloping downward, upward, or was relatively flat, all parts of the frontal body image were encoded in a vertical straight-line direction from the cloth to its corresponding and underlying points on the body (Jackson, 1989; Jackson et al., 1977; Ercoline et al., 1982). Since this correspondence exists even where the draped cloth was not originally touching the body, (for example, the area between the tip of the nose and the cheeks) the image was encoded through this empty space (Jumper, 1977; Jackson, 1977; Jackson et al., 1977).

Like the three-dimensional argument, since this unique vertically encoded information was also received by and is contained on the cloth, it too, could only have come from every part of the body directly below it.

The above are just some of the ways it can be shown that radiation coming from the body caused the images on the Shroud. However, when one considers that:

i) the 32 extraordinary itemized features are only found throughout the length and width of the Shroud's anatomi-

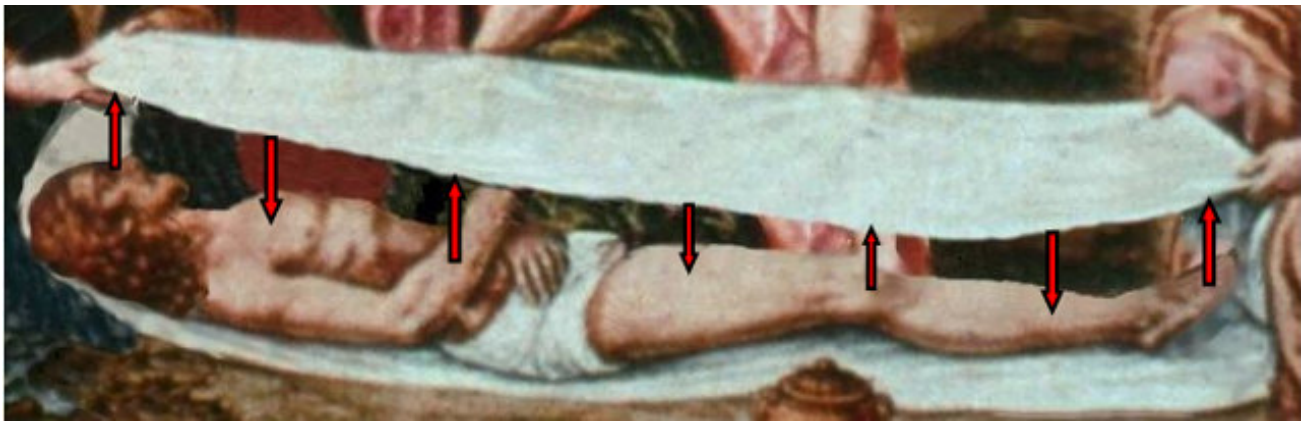

Figure 4. Illustration of vertical straight-line direction for Shroud's body image (Courtesy, Jessica Dodson and Eric Stillwell).

cally flawless frontal and dorsal body images;
ii) the full-length body images are encoded only on the interior parts of the cloth that wrapped the bloodied and crucified corpse; and
iii) all 32 itemized body image features can only be duplicated by radiation;

We can be very confident that the source of this radiation and information could only have been the body wrapped within this cloth.

PARTICLE RADIATION

In the mid-1990's, Dr. Kitty Little, a retired nuclear physicist from Britain's Atomic Energy Research Establishment in Harwell, joined the scientific debate regarding the cause of the Shroud's images. After summarizing scientific investigations of the Shroud, she confirmed "that the source of the illumination that had formed the image came from within - that is, from the body - …. as a whole." (Little, 1994) Thereafter, she stated, "Now it seemed almost certain that the image must have been caused by some sort of radiation…. However, there was one source of ionizing radiation that they did not try." (Little, 1997)

Little recalled that in 1950 she had irradiated several different cellulose fibers at the nuclear reactor in Harwell with particle radiation - radioactive illumination consisting of combinations of protons, alpha particles, neutrons and gamma rays. As we shall see, these basic building blocks of matter and energy not only account for all the Shroud's mutually inconsistent primary body image features, but also cause the cloth's secondary body image features, as well as critical non-image characteristics within this famous burial garment. While the last two forms of radiation, neutrons and gamma rays (along with electrons), certainly affect the non-image parts of the Shroud, the protons and alpha particles cause its coloration or body image. Using this illumination, Dr. Little was able to reproduce the straw-yellow color, which she learned subsequently is on the Shroud. The temperatures in the reactor's channels were as low as 40°C, so the radiation effects could be examined without the complication of heat degradation (Little, 1994, 1997).

Neutrons and protons behave very differently. Neutrons are very penetrating and, like gamma rays, easily pass through linen cloth. Protons have very short ranges; they are so non-penetrating that they even absorb or attenuate in air. Protons and alpha particles would evenly deposit their energy to produce the uniform straw yellow color - only on the topmost fibers of the cloth (Little, 1994, 1997). Moreover, they would break many of the bonds of the molecular structure of the cellulose, but only in these topmost image fibers, thereby causing some of the single-bonded carbon atoms attached to hydrogen or oxygen to, thereafter, re-form with other carbon atoms into double-bonded, or conjugated, carbonyl groups. This occurs because carbon double-bonds re-form more rapidly and effectively than other carbon combinations (Little, 1997). As the main building blocks of matter, protons, neutrons and electrons are found in immeasurable abundance in all bodies (a deuteron and an alpha particle contain one or two protons and neutrons, but both behave like a proton, in that they traverse only a short distance in air and an even shorter distance in linen. Therefore, throughout this and subsequent discussions, where protons are specifically mentioned, similar results would be expected for deuterons, alpha particles or other heavy charged particles).

In the mid-1990's, Dr. Jean-Baptiste Rinaudo of the Faculty of Medicine of Montpellier, France, began performing intriguing experiments with protons and neutrons (Rinaudo, 1998, 1996, 1994, 1992). Figure 5 shows one of his proton-irradiated linen cloth samples. Dr. Rinaudo and his associates performed numerous experiments irradiating white linen cloth with proton beams of various energies with a particle accelerator at the Grenoble

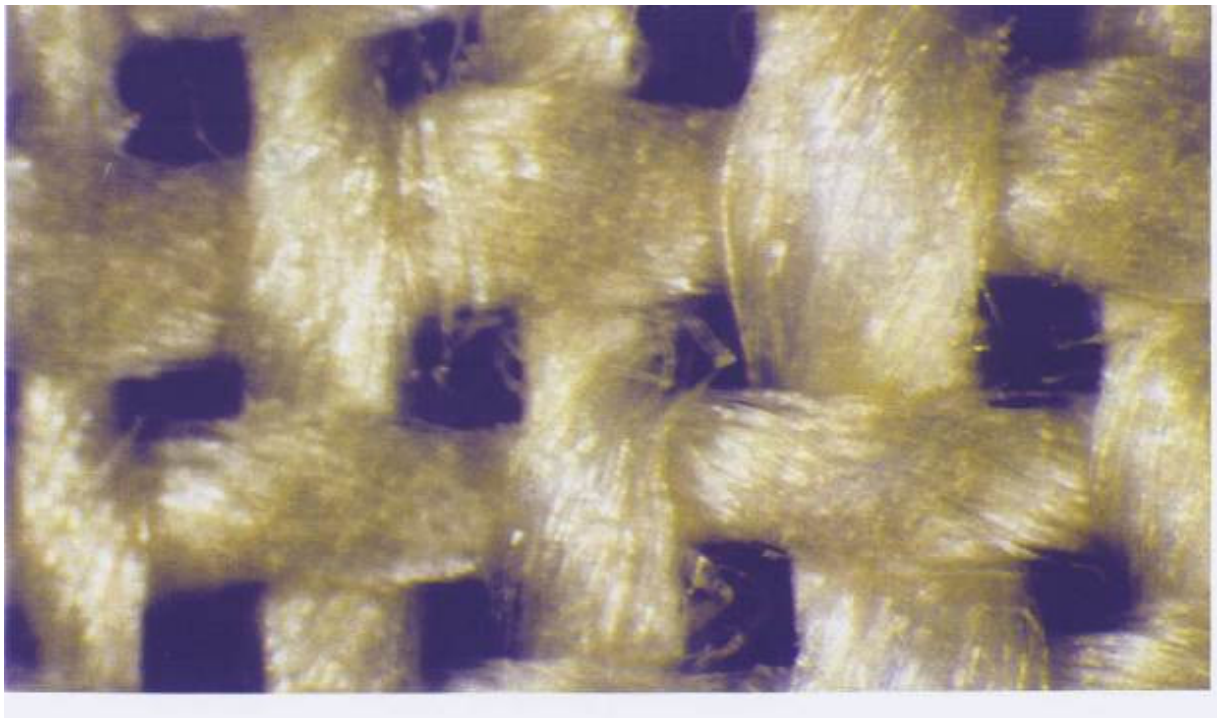

Figure 5. Photomicrograph of a proton irradiated linen cloth shows a very similar appearance to the body image area on the Shroud (Courtesy, Dr. Jean-Baptiste Rinaudo).

Nuclear Studies Center in France. Linen naturally fluoresces under ultraviolet lighting, as does the Shroud's background or off-image areas. However, when Rinaudo's experimental linen was irradiated with proton beams with energies of I.4 MeV or less, the cloth's natural fluorescence disappeared, as is the case with the Shroud's body images. The protons produced uniform superficial coloration on cloth whose fibers and threads lacked any cementation or added pigments or materials of any kind. Where body image fibers crossed, underlying fibers were protected and remained white, as found on the Shroud; in addition, the inner part of the straw-yellow image fibers remained white, like the image fibers on the Shroud. The scientists were also able to duplicate the microchemistry results of dehydratively oxidized, degraded cellulose, as is also found with the Shroud's body image (Rinaudo, 1998, 1996).

Rinaudo's straw-yellow color also resulted from conjugated carbonyl (double-bonded) groups within the molecular structure of the cellulose, as is also found with the image fibers of the Shroud. (Rinaudo, 1998; Jumper et al., 1984) These double-bonded carbon groups absorb light and reflect it as the straw-yellow color that is visible on Rinaudo's linen, as well as the Shroud linen.

Rinaudo also demonstrated that like the Shroud's coloration, his could also develop over time if the irradiated linen was artificially aged by heating at low temperatures. (Rinaudo, 1998) Like all linen, the Shroud has yellowed or darkened with age. As referenced previously, when a Shroud fiber is cut in two, its original white color can be seen on the inside. Normal darkening and degradation of cellulose (the main component of linen) occurs through gradual oxidation and loss of water by exposure to heat and light. Scientists have established that the application of either heat or light to cellulose will artificially darken it in what amounts to a rapid simulation of the aging process. The yellow body image on the Shroud is made up of "chemically altered cellulose consisting of structures formed by dehydration, oxidation and conjugation products of the linen itself" (Jumper et al., 1984).

The changes in cellulose that are known to be the result of aging are these same dehydrative and oxidative processes. Laboratory simulations by scientists using the above controlled, accelerated aging processes produce the same overall properties, as well as spectral reflectance curves, as the body image and background areas on the Shroud. The Shroud's body image fibers are more chemically degraded than the background fibers; the body images have yellowed faster and darker than the background or non-image areas on the Shroud. While radiation or some other process probably helped cause the body images to age faster than the less yellowed background, both appear to have developed over time as the result of an aging process (Jumper et al., 1984; Pellicori and Evans, 1981; Pellicori, 1980; Gray, 1977; Pellicori and Chandos, 1981; Jackson et al., 1988; Rinaudo, 1998, 1996).

Rinaudo and Little's results indicate that protons within particle radiation can duplicate or account for all of the items in the original list of 32 body image features. Rinaudo even showed how the superficial straw-yellow coloration produced could not be extracted with all types of acids, redox or solvents, but immediately disappeared with the application of diimide, like the Shroud's coloration. (Rinaudo, personal communication)

HYPOTHESIS

The original cloth collapse hypothesis by STURP physicist John Jackson was developed strictly from considerations of the Shroud's image properties after he observed that all naturalistic and artificial image creating models had been tested and failed (Jackson, 1990, 1991; Jackson et al., 1984). Dr. Jackson's model claims if the body of the man in the Shroud became insubstantial and emitted ultraviolet light that the Shroud's primary and secondary body image features could have been encoded on the cloth. While ultraviolet light is a good candidate, it has some shortcomings; however, the cloth's momentary collapse into an area of radiation once occupied by the body is a critically important concept.

The Shroud appears to have wrapped the dead body of a man who suffered all the same wounds and tortuous events that reputedly occurred to the historical Jesus Christ. It is also known that the cloth had intimate contact with the body even in the many places that the draped cloth would not have originally been in contact with the body. Yet the body has obviously left the cloth. Since no decomposition stains have been detected anywhere on the Shroud by modern technology, the body appears to have left within two to three days of having been wrapped within and acquiring intimate contact with the cloth. If the cloth had been removed from the body by any human or mechanical means - some, most or all of these intimately encoded blood marks would have been broken or smeared. For decades modern science has known that the body clearly left the cloth within two to three days, but that it did so in a mysterious manner. In light of all the information to date, we propose a more fundamental hypothesis that makes certain predictions that could be tested by future examination of the Shroud (Antonacci, 2010).

As Dr. Jackson first stated over twenty years ago in the beginning of his cloth collapse paper, "Therefore, perhaps the time has come to ask if we ought to start thinking about the Shroud in categories quite different from those that have been considered in the past. In particular, perhaps we need to be more flexible in our scientific approach and consider hypotheses that might not be found readily in conventional modern science, for it is conceivable that the Shroud image presents, if you will, some type of "new physics" that ultimately requires an extension or even revision of current concepts. … even if such a principle contradicted current concepts of science (Jackson, 1990, 1991)."

We propose a very similar and "unconventional" model. We propose that the body of the man in the Shroud became insubstantial or disintegrated possibly leaving behind a very small amount of some basic particles of matter such as protons, neutrons and, perhaps, electrons and gamma rays. The instantaneous nuclear disintergration of the body of the man in the Shroud was also proposed both by biophysicist Dr. Jean-Baptiste Rinaudo (Ridaudo, 1998, 1996, 1994, 1992) and nuclear physicist Dr. Kitty Little (Little, 1994, 1997).

The neutron fluence that would be needed to cause the radiocarbon date to be medieval instead of first century is 8.3×10^{13} $n \cdot cm^{-2}$ if the nitrogen content of the Shroud is about 570 ppm (Lind et al., 2010). This neutron fluence over the 4.4×1.1 m^2 area of the Shroud is 4×10^{18} neutrons, which weigh only 0.67 µg. Rinaudo (Rinaudo, 1998, 1996, 1994) hypothesized that an equal number of protons would also radiate from the body and they would form the image, so this would amount to a total weight of neutrons and protons of only 1.34 µg. This is an insignificant fraction of the weight of a human body.

Body image features

Let us first examine what such an event would do to the Shroud itself. The draped cloth would fall by gravity in a vertical straight-line direction into the disintegrating body (only vertical directionality, and not longitudinal or latitudinal directionality, would be encoded.) The part of the draped cloth that was originally closest to the body would have received the most particle radiation while the part originally farthest away would have received the least, yet both parts and all parts in between would have received proton radiation, and their respective amounts would have been in direct correlation to their original distances from the underlying body. This would result in true three dimensional information being encoded onto the two dimensional cloth with the lightness and darkness at each and every point of the frontal body image being directly correlated to their original distances from the body when the cloth was first draped over it.Since this image encoding event occurs rapidly, the cloth would only be partially through the body region when the radiation ceased, thus only internal skeletal features closest to the body's surface (for example the hands, face, and teeth) would become encoded just like those found on the Shroud. This also explains the dark spot underneath the high point of the man's hands and why his internal organs are not encoded. With this proposed method, there could also be discoloration or imaging on the back side of the cloth behind the face and hands (the high points of a supine body), which some scientists have identified at these locations on the back side of the Shroud (Fanti and Maggiolo, 2004).

Because the cloth fell straight down receiving heavy charged particles only from the part of the body directly underneath it, a highly detailed negative image would be encoded on the cloth. As the cloth fell into the radiant region, the heavy charged particles would stop as they struck its topmost superficial fibers while evenly distributing their energy. As the cloth oxidized and dehydrated while it aged, a superficial straw yellow discoloration consisting of conjugated carbonyls would occur on the linen fibers where they were irradiated by the protons, deuterons, and alpha particles. The colored fibers would be uniformly encoded, yet would be weaker and more corroded or friable than the non-image fibers, while having all the other characteristics listed at the beginning of this paper.

This method, called the Historically Consistent Method, not only explains all of the earlier primary features of the Shroud's body image and their fibers, but also accounts for the following secondary body image features found on the Shroud. For example, the photographic negative, positive and three-dimensional images clearly show gaps along both sides of the face and that part of the beard is upturned. The most likely explanation for these features is that a small chin band held the mouth closed (Robinson, 1977). Notice also on the photographic negative that vertical lines run down from the chin, especially below the right side of the man's beard, which is not so upturned. As the part of the cloth lying over the chin fell and flattened, it would acquire such lines or motion blurs. Perhaps more lines would be left, before the radiation ceased, in the area that did not have to fall down and through as much beard before flattening. This would be the area immediately next to where the beard was turned up on the man's right side. Notice also the wide, rectangular area of body image below the man's chin and beard. This could have been caused by the cloth's coming into contact with and encoding the neck or throat area under this model, leaving this appearance after the cloth is straightened or flattened (notice also the odd-shaped feature encoded as body image next to the neck area and below the end of the length of hair on the man's left side. This might be a displaced hair image also caused by the cloth's movement).

There are also two faint body images in the blank space off the left side of the man's face, next to the eyebrow and cheek bone (Figure 6). They, too, could be from motion blur by the cloth in this region, but their faintness, and the lack of any such image on the right side, could be due to the chin band slowing or impeding the complete collapse or encoding of the overlaying cloth in this region. In addition, the small lateral distortion at the femoral quadriceps (Ercoline et al., 1982) would most likely be encoded by a cloth collapsing.

Other subtle forms of distortion also exist on the Shroud image that is accounted for by this model. For example, this model also explains the length of the man's fingers. Under the Historically Consistent Method, the protons and alpha particles emanating from these surface bones became encoded as the cloth passed through this high portion of the supine body. Dr. Giles Carter was the first to observe that the man's fingers were bent; this position naturally remains from the crucifixion. After a two-dimensional cloth falls through and encodes curved fingers, when the cloth is then straightened or flattened, it results in a longer area of the cloth having been used to encode the fingers than if the fingers had been straight. A simple experiment with a cloth tape measure bears this out if you measure from the top of the wrist to the end of your bent fingers, and then measure again to the end of your straight fingers. The cloth tape will reveal that the first measurement is longer. Thus, the encoded fingers look somewhat longer when encoded under this method.

All of these secondary body image features are found on the Shroud, but none have even been encoded by artists on other portraits, or would have likely been encoded naturally. Only cloth collapse hypotheses can explain these very odd features as a natural consequence.

When the body suddenly disappears or disintegrates, a brief vacuum would be created (Jackson, personal communication), (Lind, personal communication) that

Figure 6. Faintly encoded blank spaces at side of face (Copyright, 1978, Vernon Miller).

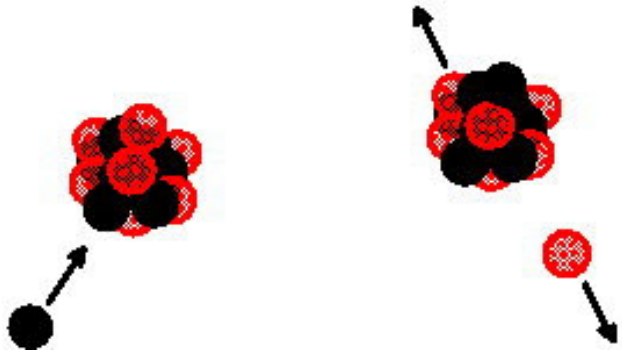

Figure 7. Before collision of neutron (black) with nitrogen-14 nucleus, 7 protons (red) and 7 neutrons. After collision, neutron is captured and proton is ejected, resulting in carbon-14 with 6 protons and 8 neutrons (Courtesy, Dr. Arthur Lind).

would draw or pull the dorsal cloth up a short distance into the body region encoding body image and blood marks on the dorsal side. All of these features would also be encoded if the body vanished or disappeared vertically in the same direction in which the cloth collapsed. Since radiation is emitted from the entire body, the amount of time that the frontal part of the image is exposed to the radiation would be equal to the dorsal part, thus leaving body images with approximately equal intensities. Since the sides of the man's body do not intersect with the collapsing cloth, they are not encoded under this method, or on the Shroud.

Particle radiation given off at the body's disintegration also explains how the faint subtle coin or flower images, if present on the Shroud, could have been encoded under this method. When some of the many neutrons that flew out of the body region hit the coin or flowers, they could have caused these objects to leave faint images on the cloth in several ways. For example, when a neutron hits the nucleus of copper, the primary component of ancient bronze coins, the nucleus can absorb the neutron and give off either a proton, alpha particle, deuterium, or a low-energy gamma ray. Each of these particles - protons, alpha particles, or deuterium, encodes superficial images on the cloth and, if they were given off the coin's surface, could encode the coin's features. Similarly, flowers contain trace amounts of heavier elements such as iron, calcium, and potassium. When any of the countless neutrons hit these three heavier elements, each could also absorb the neutrons and give off protons and alpha particles. Any protons or alpha particles given off the flowers' surfaces would also encode a superficial image on the Shroud.

Non-image effects

Recent experimental results demonstrate the well-known scientific principle that if linen, or any other nitrogen containing object, is irradiated with neutrons that carbon 14 (C-14) will be created within the irradiated linen (Lind et al., 2010). These new C-14 isotopes are converted from nitrogen (N-14) within the molecular structures of the irradiated objects by the process illustrated in Figure 7.

Unlike C-14 created by neutrons from nitrogen in air, as well as other sources of extraneous C-14, the C-14 created by neutrons from N-14 that is part of or indigenous to the linen itself remains within the molecular structure of the linen. These experiments demonstrate that such newly-created C-14 isotopes remain despite natural aging, the application of heat at temperatures that the Shroud was exposed to during the fire of 1532, or when pretreated and cleaned by all seven standard pretreatment methods that were applied to the Shroud's cloth samples in 1988. These tests and experiments even demonstrate that combinations of natural aging, as well as the above applications of heat and the above standard pretreatment cleanings, will not remove the C-14 created by particle radiation from the indigenous N-14 within linen (Lind et al., 2010). These experiments have shown that neutron particles can alter the radiocarbon date of linen by increasing its radiocarbon (C-14) content causing the irradiated linen to erroneously date 1300 years or more younger than its actual age (Lind et al., 2010).

Particle radiation emanating from the man in the Shroud can also possibly explain the cloth's excellent condition, and the still reddish color of its blood marks after all these centuries. Scientific testing and medical examination of the Shroud and its samples throughout the 20th and 21st century conclusively establish that coagulated human blood is present on the body of the man in the Shroud (Antonacci, 2000). The blood on the Shroud, however, still retains a reddish coloration. Even if the Shroud is medieval, its blood should have long ago turned dark brown or black, like other centuries-old blood. Blood will actually start turning dark within days or weeks of leaving the body and being exposed to air. The still reddish color of the blood is not only apparent to anyone who has ever seen the Shroud, but when the Shroud is exposed to sunlight, it appears to be even redder (Barbet, 1963, 1940). The late Dr. Carlo Goldoni recently undertook experiments to explain these remarkable attributes and concluded that when blood marks are first exposed to neutron irradiation and then to ultraviolet light (such as the Shroud would naturally receive from sunlight during exhibitions) it resulted in the blood marks having a bright red coloration. Dr. Goldoni found this reddish coloration existed regardless of the blood's bilirubin content, (Goldoni, 2008) which has been the traditional explanation for the Shroud's centuries-old red coloration (Adler, 1986, 1987; Jumper, 1984). Further experiments should be undertaken to build upon these initial experiments.

Regardless of its age, everyone who has ever examined the Shroud has also noted its remarkable condition. As STURP scientists Roger and Marion Gilbert remarked quite some time ago in an observation section of a scientific paper, "The cloth [Shroud] is in excellent

condition, extremely soft and pliable with no apparent degradation of strength" (Gilbert and Gilbert, 1980). This observation would still be true even if the Shroud was only 700 years old. Indeed, the Gilberts did not know the Shroud's radiocarbon age at the time of their observation. Needless to say, ancient cloth is rarely, if ever, described as "in excellent condition." The only friable parts on the Shroud are its topmost two to three fibers containing the superficial body image. Interestingly, while particle radiation may have caused the Shroud's topmost fibers to be more friable, it also explains the excellent condition of the rest of the cloth, which has never been explained previously.

As the Shroud passed through the radiant body region, the gamma rays, electrons and neutrons would actually strengthen the cloth, helping to explain its excellent condition. The Shroud's linen consists of cellulose, which contains long-chain molecules.

These molecular chains have repeating subunits that pass through crystalline, partly crystalline, and noncrystalline regions (A crystalline region has a specific internal and symmetrically arranged structure). Gamma rays, electrons, and neutrons (unlike protons and alpha particles) are long-range particles or radiations that easily pass through linen cloth. As they did, a very small fraction of them would have caused a limited number of molecular bonds to break and re-form in the noncrystalline regions, thus cross-linking these molecules and giving the cloth greater resistance to solubility, oxygenation, and chemical reactions. According to Dr. Little, "Given a high crystallinity such as one would expect to find in good quality linen… this type of cross-linking also reduces solubility and susceptibility to oxygenation and other chemical reactions, which would account for the lack of degradation and 'aging' that might be expected in a material 2,000 years old, and that had been subjected to repeated handling and ill-treatment." Dr. Little continued: "Such a reduced chemical activity would also account for the fact that although the Shroud was reported to be covered with mildew spores there were no mildew reactions, so that the fabric was unharmed" (Little, 1997).

In closing Dr. Little states, "An instantaneous disintegration of the nuclei of the atoms in the body would account for the formation of the image, detail by detail, and the good state of preservation of the linen of the Shroud" (Little, 1997).

CONCLUSION

This paper presents reasons why the Shroud's body images were caused by radiation; why the source of the radiation was the dead human body wrapped within it; that the radiation appears to be particle radiation; and that if particle radiation emanated from the disappearing body of the man in the Shroud, it could account for or explain all of the primary and secondary body image features, the excellent condition of the cloth, its back side imaging, its possible coin and flower images, and the still red color of its centuries-old blood. No other form of radiation, or naturalistic or artistic models can account for all of these features. We have also seen that particle radiation could explain the only test result among thousands performed on the Shroud of Turin that is inconsistent with the cloth's authenticity as the burial garment of the historical Jesus Christ - its 1988 medieval radiocarbon date (Damon et al., 1989). A previous study (Lind et al., 2010) confirms that particle radiation creates new C-14 isotopes from the nitrogen (N-14) isotopes indigenous to the irradiated linen. These newly-created C-14 isotopes stay within the molecular structure of the irradiated linen despite natural aging, the application of heat at temperatures that the Shroud was exposed to during the fire of 1532, or when pretreated and cleaned by the same pretreatment methods applied to the Shroud in 1988. In this manner, neutron particles could alter the radiocarbon date of irradiated linen by 1300 years or more.

The keynote address given at the international conference held in Frascati, Italy in conjunction with the Shroud's Exhibition in 2010 laid out an extensive series of scientific tests to be performed on the Shroud of Turin itself, as well as its linen, blood, and charred samples, and on limestone from Jesus' reputed burial tomb(s) (Antonacci, 2010). Among other things, this address calls for the measurement by Accelerator Mass Spectrometry of Cl-36, Ca-41 and C-14 isotopes in the above samples. If Cl-36 and Ca-41 can be detected in these samples above their infinitesimally small background levels, it would indicate that they were irradiated with particle radiation. Such findings, combined with the findings and analysis of this paper and its references, would not only indicate that particle radiation irradiated the various samples, but the source of the particle radiation was the length, width and depth of the dead body wrapped within the Shroud. The keynote address further explains how the amount of particle radiation and the actual age of the Shroud and its blood can be calculated with the same accuracy as radiocarbon dating.

The Frascati paper also explains that these scientific tests could even determine where this unprecedented event occurred and when it happened. The findings and analysis of this paper combined with the test results from the keynote address could indicate that a miraculous event not only occurred to the man in the Shroud, but that this event was consistent with the reputed time, place and resurrection of the historical Jesus Christ.

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