The Nature of the Body Images on the Shroud of Turin

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ABSTRACT: *The Shroud of Turin is a 4.4 X 1.1 m linen cloth bearing the front and back body images, accompanied by blood images, of what appears to be a crucified man. As it is alleged to be the actual burial cloth of Jesus, it is a most controversial object. Many of those not accepting this claim have asserted that it is just a painting, although it is now clear that the blood images are due to the cloth having been in contact with a wounded human body. A large body of scientific evidence has now been accumulated on this object and will be reviewed in some detail, including the question of authenticity. It will be clear that it is not a painting, nor any of several other recently suggested explanations such as a photograph, although the mechanism of the formation of the body images remains a mystery. Matters concerning its conservation will also be briefly touched upon.*

INTRODUCTION: As it is alleged to be the authentic burial cloth of Jesus, the Shroud of Turin has long been an object of religious and historical controversy. It became an object of scientific polemic, also, in response to the work of Vignon (1) and Barbet (2) at the beginning of this century. The scientific investigations following these pioneering studies have continued this polemic, but have also deeply broadened our understanding of this remarkable object.

Many different types of investigators employing a large variety of investigative techniques have contributed to this large corpus of scientific information concerning the Shroud and their work is reported in many general and specialized reviews, monographs, conference proceedings, and professional journal publications (3-33)**.**

Scientific conclusions must be based on repeatable testable experiments, e.g., one can only test for the disauthenticity of the Shroud as no acceptable laboratory test exists that will establish the identity of the man whose image is shown on the cloth (3, 4). Similarly, one must be careful in matters of alternate hypotheses, random and systematic errors, sensitivity of measurement, interferences, being concerned with standards and controls and being sure that conclusions drawn from microstudies are in agreement with those seen at the macrolevel (3). This is a special problem with the Shroud in that the micro-investigations are based on sticky tape samples taken

from the surface of the cloth and therefore contain much mechanically translocated and adventitious debris (3, 4, 24). This includes contact transfer of artist's pigments from the historically documented four dozen or so artist's copies of this image that have been "sanctified" by pressing the two images together (34). Therefore the presence of such material does not prove that an artist painted the images, but only that it has been in the presence of artists making copies of the image (3,4, 24, 34, 35, 36). Scientific "truth" is based on the accumulation of a corpus of logically consistent probabilities (3).

BLOOD IMAGES: There are a number of different kinds of marks, stains, and images on the cloth of the Shroud (5). It should be noted that while most interest has centered on the blood and body images, the other marks do provide some scientific information, e.g., historic (37). The burns, scorches, and waterstains are readily accounted for by the historically documented 1532 fire (37). However, the scorches give an orange fluorescence under ultraviolet excitation, while the body images do not fluoresce (25), thereby ruling out any scorching methods for the formation of the body images (3,5,6, 24). At the interfaces between the waterstains and/or burns and the body images, no evidence is seen for changes in the appearance of the image color if were due to an applied inorganic or organic pigment (3,5,6, 7, 24). It should be noted that this observation specifically rules against iron oxides as the body image chromophore, since at the microlevel the color of the body image fibers is a straw yellow. The only known forms of iron oxides that are this color are hydrated ferrous forms (38) which therefore would be discolored by the fire (3).

Although they sometimes differ on certain matters, all of the medical forensic examinations of the blood images are in agreement that they were exudates from clotted wounds transferred to the cloth by its being in contact with a wounded human male body consistent with the historic descriptions given for the Crucifixion of Christ (2,3,4, 5,8,9,10, 12,13,14,15,16,17,18,39,40). This conclusion is also consistent with the computer imaging evidence (28). A simple masking transfer experiment (3,4,17,41) has shown that the body images are out of stereoregister with the blood images and therefore have gotten onto the cloth by a non-contact information projective process. This is in agreement with the original observations of Vignon (1,3) and the more recent computer imaging studies (3,11, 28, 42). Enzymatic removal of the blood from a blood coated fiber reveals that the blood got on the cloth first and therefore protected the blood covered areas of the cloth from the image forming process (3,5,24). All the microscopic, chemical, spectroscopic, and immunological evidence is consistent with these images, not only being exudates from clotted wounds, but those of a man who suffered severe trauma prior to death, explaining the red color of the blood at the microscopic level (3,4,5,8,11,12, 24,29,30,31,32,33,43,44). Proposed mineral compositions simulating blood are not consistent with these various measured chemical and physical parameters(3,5,12,24,29,30,44).That these are clotted wound exudates is clearly seen in the ultraviolet photographs where every single blood wound shows a distinct serum clot retraction ring (25) agreeing with the earlier observations of the pioneers on the major blood wounds as seen directly on the cloth (1,2,3). It is clear that we can explain the presence of the blood images on the cloth consistent with their alleged origin.

Note that any attempt to explain the formation of the body images must take these properties of the blood images into account. One cannot simply say that the blood images were painted on afterwards. One would need a constant supply of fresh clot exudates from a traumatically wounded human to paint in all the forensically correct images in the proper non-stereo register and then finally paint a serum contraction ring about every wound. Logic suggests that this is not something a forger or artisan before the present century would not only know how to do, but even know that it was required.

BODY IMAGES: The sticky tape samples were subjected to exhaustive wet chemical analysis after the problem of dealing with the debris and classifying the different fiber types and particles present that were pertinent to the Shroud (24,44). The tests were for the presence of proteins (by stains and enzymes), blood components, metallic species, organic structures and functional groups, and, also, solubility by a large series of solvents (24). The results of these tests were that proteins could only be detected in materials from the blood images, that the blood image materials were those anticipated as derivable from clotted blood, the only metallic species present were covalently linked calcium and iron that could be accounted for as products of the retting process converting flax to linen, iron oxide could only be demonstrated in materials from the blood scorch and waterstain areas where its natural occurrence could be anticipated, the only functional groups present were those associated with the cellulose of the linen itself or its dehydrative oxidation products, and solvents did not extract the image chromophore which also could only be bleached by very strong redox agents (24). Therefore it was concluded that no applied dyes, stains, or pigments, were present and the image chromophore was a conjugated carbonyl produced in the cellulose structure itself by a dehydrative oxidation process (5,24). These results and conclusions have been confirmed by a variety of spectroscopic investigations (3,4,5, 6,12,29,30,31,32,33,37,44).

Microscopic examinations of the image areas have revealed a number of interesting physical properties of the image (3,4,5,6,26) that must be met in any proposed formation mechanism as well as meeting the observed chemical and forensic properties cited above. The image only goes one fiber deep lying on top of the crowns of the treads of the weave of the cloth (unlike the blood images whlch do penetrate the cloth as they are an “applied” material). The fibers are not cemented together (no binders present), but the image process shows no evidence of capillarity, i.e., the image does not appear under any crossing fibers, and the image fibers are very brittle and show “corroded” surfaces (as would be expected for dehydratively oxidized material). All the colored fibers are uniformly colored, i.e., an exposed fiber is either colored or not colored. This demonstrates that the image seen at the macroscopic level is an areal density image and not a pigment concentration image. Shading. is not accomplished by varying the ‘color’, but by varying the number of colored fibers per unit area at the microlevel. Rubbing these fibers with a teasing needle does not reveal any adherant applied powders to be present, nor can any be seen at high magnification.

However,the most interesting characteristic of the images is revealed by computer imaging analysis, particularly that done by a VP-8 image analyzer (3,5,11,28,42). The body image contains realistic 3-dimensional information relating image density at any particular pixel point to

the distance between the cloth and the body at that point. Further, this projective information transfer can be shown to be collimated and anisotropic, neither necessarily orthogonal to the receiving or sending surface (28) Note, no image appears between the two body image heads as would be consistent with this point. Although we do not have any confirmed explanation for this property, it has been used to test a number of artistic rendition methods and they have all failed to meet this criterion (28). These methods include albedo (simple reflection as in an ordinary photograph) images from a bust, phosphorescent emission images from this same bust, artistic sketches and paintings of various types, chemical contact images, thermal images, diffusion images, bas reliefs, dry powder contact images, scorching contact with an engraving, and various hybrid mechanisms (28). These conclusions are in agreement with those earlier reached by a comparison of possible formation mechanisms with the observed scientific data (6) and interestingly enough with many of those ruled out by Vignon (1) in his pioneering studies. It is also of interest to note that starting with artistic criteria, rather than scientific, it can be demonstrated that the Shroud is not a painting (36).

ENZYMATIC STUDIES: At the Nice conference, Mottin suggested that the background fluorescence of the Shroud might be due to the presence of pectic substances not removed by primitive retting methods (45). As even modern linens may contain of the order of 2% of such materials (46), it was deemed worthwhile to test this hypothesis. The present stain of choice is ruthenium red (47). A sample of this reagent was obtained from Sigma Chemical Co. and used according to their directions. Two controls were prepared using samples of Spanish linen previously utilized for these purposes (24) and some commercial apple pectin from a health food store and sodium α-D galactouronic acid (Sigma Chemical), the major constituent in these materials (48). Two non-image area fibers did give positive indicative tests. However, some of the basic dyes (amido black and methylene blue) formerly employed in the protein testing (24) also stained the controls (opening the possibility that some former identifications of protein films on sticky tape samples may have actually been pectic substances).

In order to improve the specificity of these observations and to further check some other desired points, it was decided to resort as in the original chemical study (24) to enzymes. For example, lysozyme, trypsin, and carboxypeptidase were used to definitively resolve where proteins were or were not on what sticky tape samples (24). Samples of pectinase, cellulase, protease, lipase, and esterase were obtained from Sigma Chemical and employed according to their directions. They were tested against the Spanish linen controls and a commercial sample of polyester ribbon. Sticky tape non-image, image, and serum coated fibers were extracted from the tapes, cleaned, and characterized as in previous studies (4,24,44) and tested along with a number of fibers from the radiocarbon threads employed in the FTIR studies (4,44). The protease was only active against the serum coated fibers and as in the previous study (24) revealed smooth, non-corroded fiber surfaces indicating that the blood images went onto the cloth before the image forming process and protected the underlying cloth. Pectinase, and also the cellulase (but much more slowly than the pectinase) showed positive action against the non-image and radiocarbon fibers and did nothing with the image fibers in the same time period. It would appear that Mottin's hypothesis is correct, pectic substances are present, but the matter should still be

confirmed by spectral analysis. Evidently they remain under the salt encrusted coating (4,37,44) found on the radiocarbon samples, also. Finally, the lipase and esterase show no activity whatsoever against any of the Shroud fibers, but are quite active against the commercial polyester control.

IMAGE FORMATION MECHANISMS: In general, most of the mechanisms discussed fail because they either fail to recognize or to selectively misrecognize the criteria set forth above. They also fail to deal correctly with the problem that the blood images cannot simply be painted on after the image formation process. It is not sufficient to just produce a body image of what appears to be the right color. It must meet all of the chemical as well as the physical criteria that have been established.

In "Judgement Day for the Turin Shroud", McCrone repeats his continued argument that the Shroud is a painting. It should be pointed out that the problem has more to do with how he interprets what he sees than the observations itself. He examined the sticky tapes under a microscope and saw iron oxide particles, occasional artist's pigments such as cinnabar, and fibers that seemed to have a thin film on them that stained with a basic dye as would a protein. He decided these observations were sufficient to declare the Shroud a painting. He simply has never accepted the work of other investigators showing this was a hasty judgement on his part and that his observations have alternate interpretations (3,4,5,6,8,12,24,36). There is little point in repeating all these refutations here as many of them have been described above or repeatedly in the references cited. A higher court has repealed his judgement.

Craig and Bresee (50) have described a dry powder transfer technique that appears to give acceptable VP-8 characteristics. This sounds satisfactory until one discovers they are actually making the copy from an image of the Shroud face itself. The question then becomes where did the artist get the original from which to make the copy. What would happen if one tried this only by looking at a real face? There is no observed microscopic, chemical, or spectroscopic evidence for the presence of their required dry powder. They also do not deal with the blood image problem or explain the chemical changes seen in the cellulose. This is an interesting try, but it really does not make it.

In "The Jesus Conspiracy", Kersten and Gruber (51) describe an image formation mechanism based on coating a human body with an herbal unguent mixture, enveloping the body with a cloth, and then inducing sweating to produce a Shroud "like" image. As this is a contact mechanism, it will fail the VP-8 test. There is no microscopic, chemical, or spectroscopic evidence for any of these herbal stains.They do not deal with the blood image problem. This mechanism has nothing going for it, unlike the book itself which certainly is polemical.

In "The Second Messiah", Knight and Lomas (52) assign the image on the Shroud to de Molay, as a way of coping with the radiocarbon dating problem. Their mechanism mixes supported contact for the dorsal image and a diffusional process for the frontal image. Neither will VP-8 correctly, nor register with contact blood images correctly. However, they do admit that they do not seem to have gotten it all just right and appeal to literature mechanisms as a fallback position. Note, they accept the validity of the reported radiocarbon date.

In “Turin Shroud”, Picknett and Prince (53), assign the image on the Shroud to Leonardo. They propose a photochemical mechanism with sunlight reflected from a statue via optics to image on sheet of cloth charged with a mixture of egg white and chromium salts. As this is an albedo image, it will fail a VP-8 test and there is no chemical or spectroscopic evidence for their chemical sensitizers. They do not deal with the blood image problem. Leonardo may rest easily in his grave.

Allen (54) has proposed a variation of the method just examined except that his charging photosensizers are silver salts. The receiving cloth is a crude photographic plate. It is still an albedo image and will fail a VP-8 test and there is no microscopic, chemical, or spectroscopic evidence for silver species or the expected products of their chemical reaction on the Shroud body image areas or sticky tape samples. He does not really deal with the blood image problem, either.The Shroud is not a “photograph”.

In “The DNA of God?”, Garza-Valdez makes a large number of extravagant claims, many of them self contradictory, at odds with accepted Shroud scientific literature, or at odds with basic accepted biochemical, chemical, or physical knowledge. This is illustrated by the DNA claim.

The problem with the DNA claim is not that human DNA was isolated, but in identifying whose DNA it is. The Shroud has been contaminated by human contact countless times, offering many problems in this type of analysis (56). This is particularly true for blood samples (56) and for old (57) blood samples in particular. Mature human red blood cells are enucleate and heme containing materials inhibit the amplifying enzymes(57). This is illustrated by the recent difficulties reported by Ludes (58) in an attempted analysis of a royal French blood sample from 1832. Nor does Valdez help his own case any when later in the book he claims that the hemoglobin present is some other type of Soret absorbing material i.e., porphyrin structure. He suggests cytochrome-*f* , bacteriochlorophyll, or cytochrome oxidase. These are all readily spectroscopically distinguished from hemoglobin ((59,60,61) and the first two are only associated with non-mammalian photosynthesizing systems which hardly helps making a case for the provenance of the alleged human DNA. His own collaborator, Tryon, has admitted to problems with the provenance. It is hardly surprising that the ecclesiastic officials have refused to accept the validity of this work.

His next major contention is that the entire cloth is more or less covered by a bioplastic coating deposited by a novel microbe that he himself has discovered in the Shroud samples in his possession. He claims this bioplastic has corrupted the radiocarbon date and even suggests that the microbes may be responsible for creating the body image by depositing more material in the image areas than in the background, ignoring the observed fact that the background fluoresces while the image areas do not. Are we to take seriously the notion that such microbial growth could produce the VP-8 characteristic? It should be noted that to corrupt the observed radiodate from a first century date to that reported (62) requires about a 50% increase in the C14 mole fraction. This is a prodigious amount of bacterial metabolism. Even if we ignore the Second Law of Thermodynamics and only satisfy the First Law, where does all this energy for growth come from? Are the organisms photosynthetic? Where does the mass come from? Does this

microorganism fix the nitrogen from air as required for its growth and metabolism? Where does it get its sulfur, phosphorus, and minerals from and to where have they disappeared?

The bioplastic has been identified as a polyester (55). This is of interest since although he claims it is pervasive this amount of polyester is not seen in the whole cloth infrared spectral studies (33), nor in the micro FTIR fiber studies (4,44), nor in the enzymatic studies described above. Clearly, there is a difference of opinion as to the amounts of this material that are on the cloth. There is also a problem with his claim that this material resists attack by alkali and that has prevented the decontamination of the radiocarbon samples. The care labels on polyester fabrics make it clear that they are subject to attack by alkalis and it should be noted that the ready alkaline hydrolysis of esters is the whole basis of the soap industry. It seems that his evidence for large amounts is based on what he sees in a microscope. Looking at his micrographs, however, gives us pause for new concerns. He shows us a magnified picture of the weave of the whole cloth and says see how shiny it is — bioplastic coated. Unfortunately, he seems to be unaware that all linen looks like this. It is called luster and it is one of the characteristics by which linen is distinguished from other fabrics (63,64,65). For many of the pictures of what appear to be entubulated fibers a question arises as to whether one is really seeing tubes or only diffraction artifacts, as the smaller objects in the field show pronounced diffraction rings, indicating that the field is simply out of focus. His work lacks hard convincing quantitative evidence on which one can judge the merit of his claims (cf.the papers reported by Jackson and also by Walsh at this meeting).

Finally we come to the attempted radiodating that went wrong. An alleged sample of Shroud cloth was treated with cellulase in a tris-borate buffer, ultrafiltered, lyophilized, and then sent off to two labs for radiodating (note; no quantitation, no purification, and no characterization). The dates came back 3000 and 2200 B.C. He claims no one told him that tris stood for Tris(hydroxymethyl) amino methane, an organic compound made from petroleum feed stocks and therefore whose C14 content would have gone through multiple half-lives. Therefore the tris, still present in the samples would be diluting out the C14 content of the glucose from the uncontaminated core of the cellulose and corrupting the date.

It is with some interest to note that by applying some chemical thinking that we can uncorrupt this date. Enzymatic reactions are reversible and require buffer control, but will be promoted if something complexes the released product (Le Chatelier's principle). Boric acid makes complexes with polyhydroxyl compounds like both tris and glucose (66). Speculate that the tris boric acid employed therefore was a one to one complex. What will happen? The enzymatic reaction will proceed until all the boric acid is complexed with the glucose, the pH will change, the enzymatic action will stop and one can ultrafilter off the undigested material. However, this leaves the glucose and the tris in a one to one stoichiometric ratio. Glucose contains six carbon and tris contains four carbons. Therefore the C14 content of the glucose has been diluted by 40%. Take the reported dates and their mean, plug the dates into the radioactive decay formula, calculate the C14 ratio, numerically undilute the observed C14 content and then recalculate the uncorrupted dates.

The uncorrupted calendar date corresponding to 2200 B.C. is 1151 A.D. or to within our error range in agreement with the reported radiodate (62). The date corresponding to the mean

2600 B.C. is 752 A.D. or in agreement with the studies challenging the accuracy of the radiodate and linking a set of Shroud blood images to a set on the Cloth of Oviedo (4). Finally, the date corresponding to 3000 B.C. is 351 A.D. or to within our errors could be taken as evidence for a 1st century date. One should not get too carried away with these dates. We still do not know the provenance of the sample, we still have no measure of accuracy, the precision is poor, we have ignored all the usual corrections to such dates, and the chemical preparations of the sample are entirely inadequate. This study well illustrates the point that a poor selection and preparation of the sample prior to sending it for radiocarbon dating can only lead to a polemical date (67).

Never the less, this date has many implications. It does give us some evidence that the Shroud really is a first century object and that our only problem in getting an accurate date is a chemical problem, as suggested by the "fire model" (68), the theoretical work supporting this model (69),and the recent experimental work confirming the original studies (cf. the paper by Moroni reported at this meeting). We do no have to invoke any unexplainable sources of particle radiation to explain the date. By reverse reasoning, we therefore can reject all such "miracle" particle radiation mechanisms from consideration in image formation processes. We have obtained a clean separation between matters of faith and science.

This leaves us with only one more proposed image formation mechanism. Several people have championed a coronal discharge mechanism (18,70,71) and their experiments have provided samples (tested by the author of this paper) that come very close to meeting both the chemical and physical criteria. However, the images have always been of thin objects and one could not apply a meaningful VP-8 test. Mills (71) originally suggested ball lightning as a natural source for this discharge — being rare, but not impossible. Unfortunately, the stability requirements faced here make this too unlikely. Fortunately this past summer, a mechanism generating such fields in seismic disturbances in piezoelectric rock chambers has been advanced and would seem to meet all our requirements (72). In further support of this mechanism is the observation that the Shroud image seems to show some underlying skeletal character, as in an X-ray image (18,73). In a high voltage, high frequency electric field, this could be viewed as field emission from the calcium of the skeleton to the calcium laden cloth as a detector in a resonance radiation process. While this is all highly speculative, it can all be tested by experiment.

Are we really seeing the light at the end of the tunnel here? Are we in reach of getting the dating problem resolved, a natural explanation for the formation of the body images, and a separation between historic authenticity matters and science that can then be devoted to preservation and conservation issues (74)? Only further research will tell.

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