THE IMAGE FORMATION PROCESS OF THE SHROUD OF TURIN AND ITS SIMILARITIES TO VOLCKRINGER PATTERNS

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SUMMARY

A new hypothesis concerning the formation of the body image on the Shroud of Turin is postulated: i.e., that lactic acid contained in the perspiration of the man on the Shroud was responsible for causing cellulose degradation in the linen cloth. Two mechanisms are assumed in the production of the image: a direct contact process; and a molecular diffusion process, in which lactic acid diffused through short distances to the cloth. This hypothesis was reached by comparing the imprints of pressed leaves with the Shroud body image. When leaves are pressed between two sheets of paper and left undisturbed for many years, "Volckringer patterns" form. Volckringer patterns and the Shroud body image are similar in spectral reflectance characteristics, UV fluorescence characteristics, sharpness of image detail, negativity and in 3-Dimensional reconstruction using a VP-8 image analyzer. The image formation process of Volckringer patterns operate long after the object is removed or degenerated; the Shroud image could also be similar to Volckringer patterns in that it might have appeared after the passage of time. It is suggested that Volckringer pattern formation and Shroud body-image formation occurred in the same way.

Over the years, many hypotheses have been proposed regarding the image formation process of the Shroud of Turin. One hypothesis is that the Shroud is a painting. Walter McCrone has proposed that an artist used iron oxide in an animal protein binder.[5,6,7]

Iron oxide has been a pigment used by artists for hundreds of years. The discovery of this on fibrils of the Shroud posed a great problem for its authenticity. McCrone's discovery of a protein binder (tempera made from collagen), based on a biochemical test known as amido black, also seemed to cast doubt on the relic's authenticity.[6] If the Shroud is indeed a painting, we must show that the concentration of pigments is high enough to account for the entire body image. We must also verify the presence of a protein binder on the Shroud. Samuel Pellicori has shown that "the body image does not contain enough iron to contribute to its visibility".[2] In addition, John Heller, using very sophisticated tests, found no greater amounts of iron in the image area than in the non-image (control) areas.[2,4] Obviously if an iron oxide pigment had been used to paint the image, we would expect the concentration of this pigment to be higher in the image areas than in the non-image areas. Since this is not the case, it appears that the body image is not made up of iron oxide.

Then where did the iron oxide originate? It has been suggested that much of it is due to a step in the ancient manufacturing process of linen. [2,4] When flax was converted to linen, it was soaked in water for

long periods. During this process (known as the retting process), the fabric picked up iron by an ion exchange process. Thus the presence of iron on the Shroud can be explained.

Other pigments, such as vermillion (mercuric sulfide), have been identified by McCrone.[7] This can be explained by the fact that the Shroud has been copied by artists many times, and it is likely that their pigments may have contaminated the Shroud.[4] It should also be noted that the iron found on the Shroud was free of such elements as manganese, cobalt, nickel, and aluminum, [4] substances contained in artists' iron pigments. Their absence confirms that the iron did not come from an artist's pigment.

McCrone's discovery of protein tempera on the Shroud by the amido black test has been contradicted by others. John Heller and Alan Adler, using very sensitive protein tests, have shown that there is no protein in the image-only areas of the Shroud.[4] This would rule out the possibility that any paint medium was used to produce the body image. It should be mentioned that protein was found in the blood areas only, and this is what one would expect in real blood.[4] Adler and Heller also identified heme derivatives, bile pigments, and albumins in the blood areas, thus confirming that the blood on the Shroud is indeed whole blood.[4] It seems unlikely that the Shroud is a painting since neither pigments nor protein tempera make up the visible body image.

A second hypothesis is that the image was produced by a burst of radiation (heat or light) acting over a short period of time, thus scorching the cloth. Scientists have tried to duplicate the Shroud body image by scorching methods and have not succeeded.[2] Also in visible light the scorched areas from the 1532 fire are similar to the Shroud body image, but spectrally they are slightly redder.[9] Thus the color of the Shroud image differs from a scorch. Finally, under UV light the scorches from the 1532 fire emit reddish fluorescence but the Shroud body image does not fluoresce.[9] These inconsistencies have led many investigators to doubt the radiation hypothesis.

A third hypothesis, known as the vaporgraphic hypothesis, was proposed by a French biologist, Paul Vignon, in the early 1900's.[1,12] Vignon postulated that the body was covered with perspiration, which contains urea: the urea formed a carbonate of ammonia, giving off ammonia vapors from the body. The diffusion of the ammonia vapors reacted with the spices on the cloth to produce the image: i.e., a chemical reaction between the ammonia and the spices darkened the fabric to form the body image.[1] This hypothesis has been ruled out because calculations show that the diffusion of ammonia would produce a blurry image, not one with fine resolution as is seen on the Shroud.[10] Also there would be diffusion of ammonia into the cloth and the image produced would not be confined to the surface.[10] Thus, as stated, the vaporgraphic theory is inaccurate. We will discuss this

further later on and try to resolve it.

A fourth hypothesis, proposed by Samuel Pellicori, is known as the "Latent Image, Cellulose Degradation" theory.[2] According to this theory, "Natural skin substances or applied burial ointments were transferred to the Shroud by direct contact with the body. These materials acted as the catalysts necessary to accelerate the degradation of cellulose at those points where contact was made. With the passage of time, an image formed. The original substances have disappeared, either through washing or by being consumed in the reaction."[9] Pellicori has substantiated his theory by impregnating linen with different substances (perspiration, oils, etc.) and air-baking them in an oven to simulate aging. His results are spectrally very similar to the Shroud body image.[2,8,9]

Another factor to be considered is that "The high resolution details present in the scourges, in particular, on UV fluorescence photos" could only be explained by direct contact between the cloth and body.[9] The problem with this theory is that if the face was produced by direct contact one would expect distortion.[9] But very little distortion is seen on the face of the man of the Shroud.

Thus while Pellicori's hypothesis might explain some of the features of the torso that came into direct contact with the cloth, it does not explain how the image of the face was produced with high resolution. Also deep features of the face, such as the eye sockets, would not be touched by a stiff linen cloth.[9]

It is possible to resolve some of these discrepancies. Nature may have supplied us with a miniature example of how the Shroud body image was produced.

When certain plant matter, such as a leaf or a flower, is placed in a book and left undisturbed for a period of many years, there develops on both the upper and lower sheets of paper a faint sepia-colored image of the plant matter (hereafter referred to as Volckringer patterns). (Fig. 1, 2) The first scientific study of this phenomenon was done in the 1940's by Jean Volckringer at St. Joseph's Hospital in Paris.[11] Dr. Pierre Barbet, well-known for his medical analysis of the Shroud, noticed that these faint sepia-colored images closely resembled the body image on the Shroud of Turin.[1] As in the Shroud body image, a great amount of detail of the plant matter was reproduced on the paper. For example, the very small veins of the leaves could be clearly distinguished. In Fig. 2, the image of the leaf on the paper appears to be a negative. When photographed, a positive image appears on the negative film, similar to what happens when the Shroud of Turin is photographed.[1,14]

I have done a quantitative color comparison between the Volckringer patterns and the Shroud body image. Using a spectrophotometer, I obtained visible spectral reflectance data from Volckringer

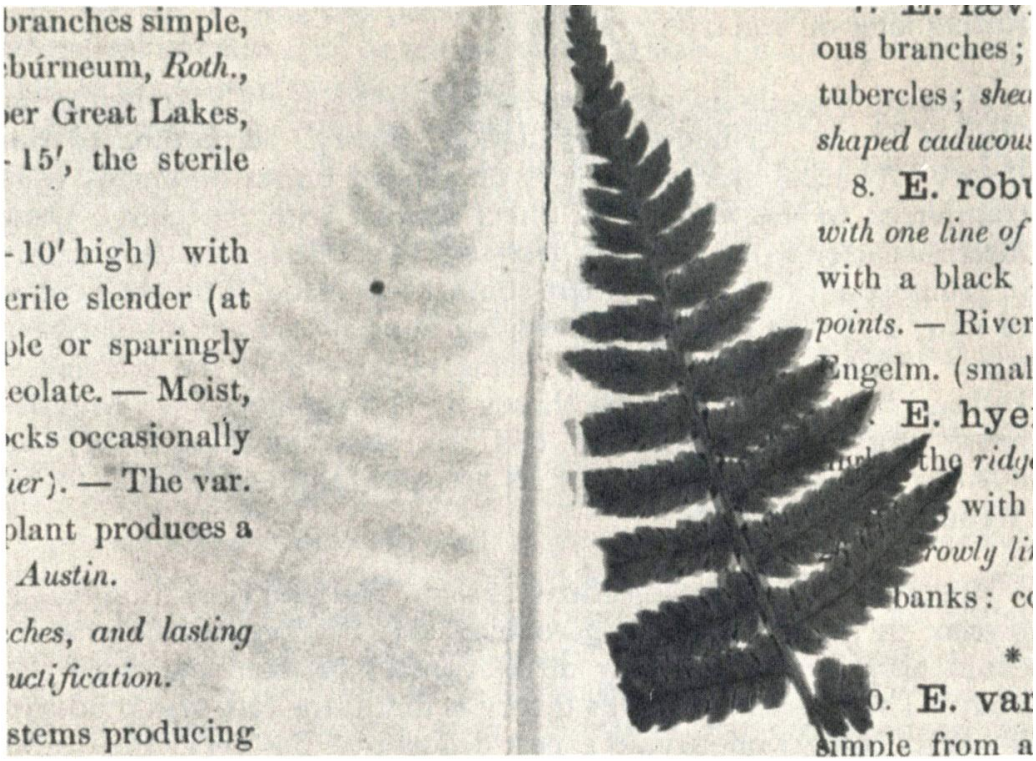

Fig. 1—Volckringer patterns formed by a fern leaf.

Fig. 2—Negative and positive Volckringer patterns.

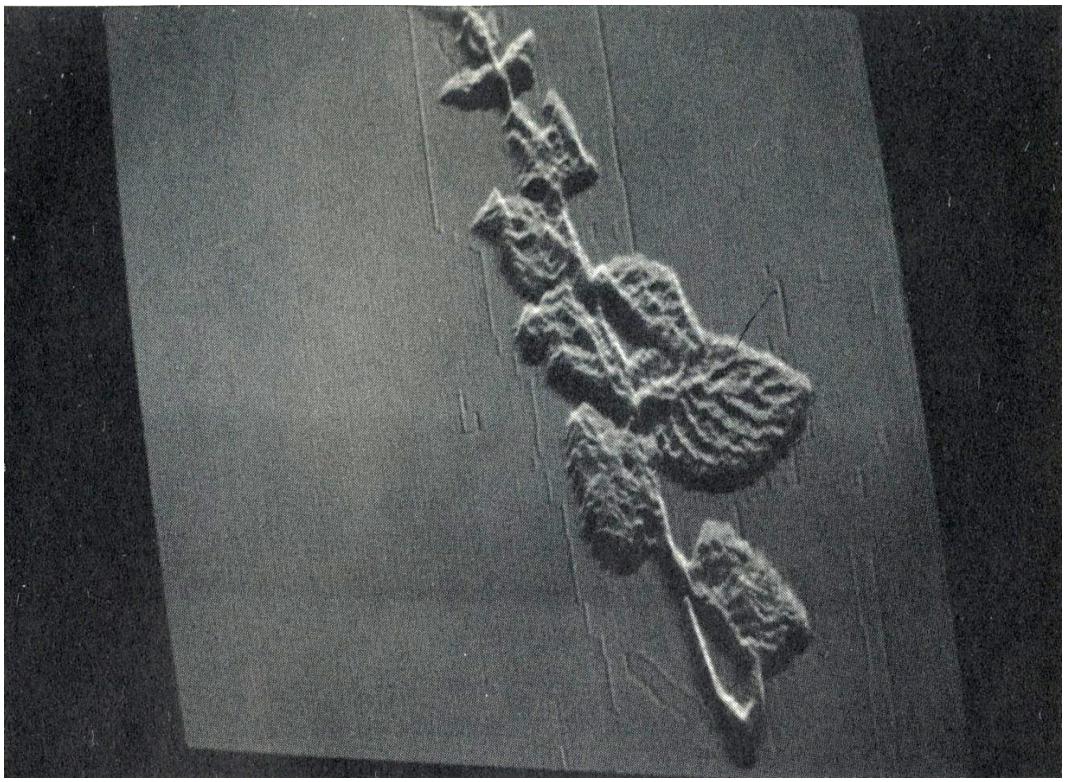

Fig. 4—Volckringer pattern reconstructed in 3-D using a VP-8 image analyser.

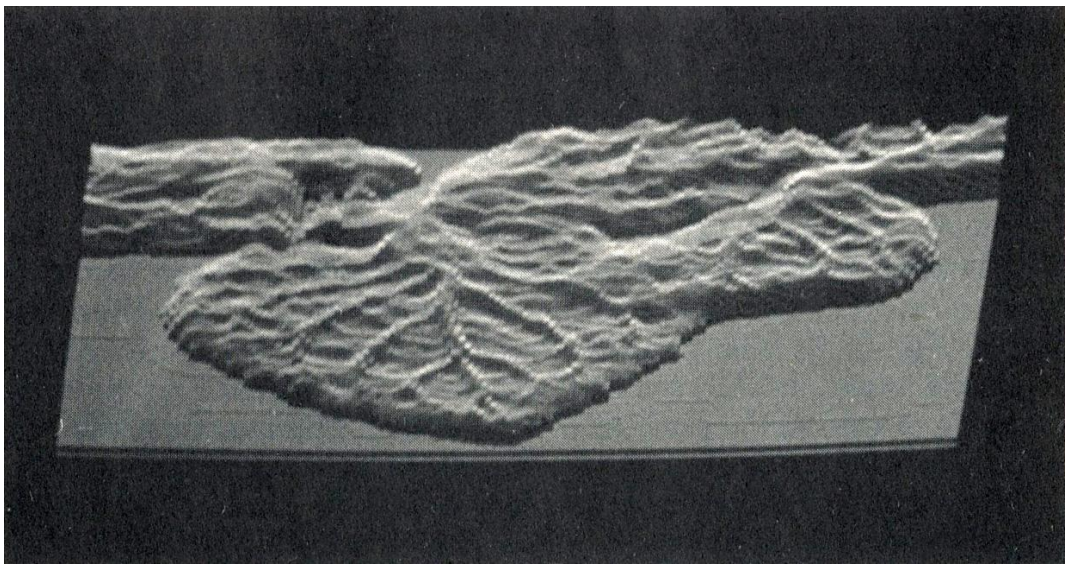

Fig. 5—Same Volckringer pattern as in Fig. 4 reconstructed in 3-D at a different angle.

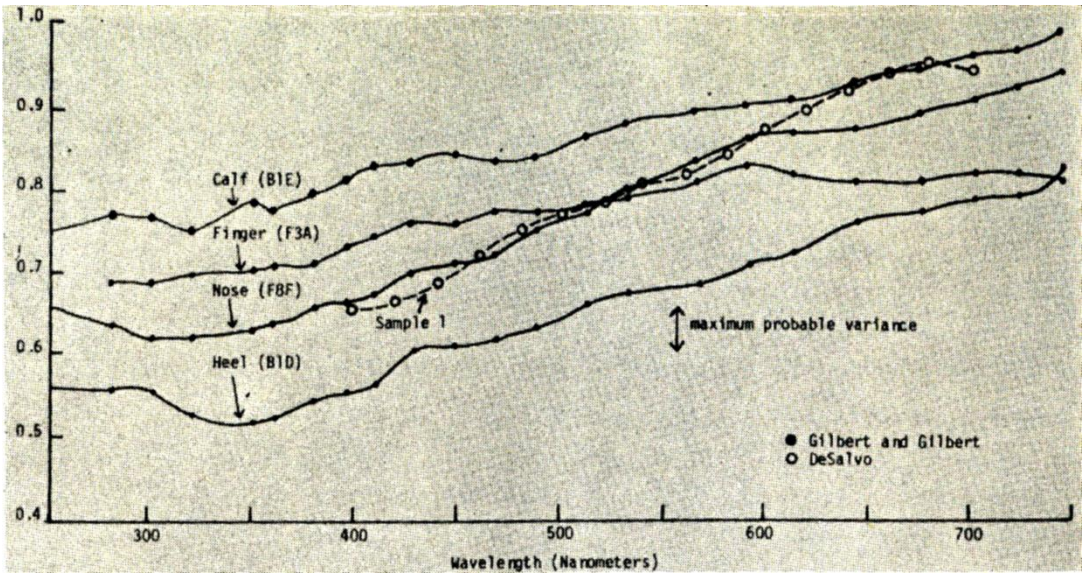

Fig. 3—Spectral reflectance data of specific Shroud body areas compared with a typical Volckringer pattern.

patterns and compared them to the reflectance data of the Shroud body image obtained by Roger and Marion Gilbert in 1978.[3] The comparison shows that specific Shroud body areas are almost identical to a typical Volckringer pattern. (Fig. 3) Another of my studies showed that the Volckringer patterns do not fluoresce under UV light. This is consistent with the Shroud body image, which also does not fluoresce under UV light. It should be noted that both the linen Shroud and the paper on which the Volckringer patterns are produced have a high cellulose content.

Pellicori proposed that the image did not appear on the Shroud until after a passage of time.[9] This also seems to be true in the Volckringer patterns. The plant dries up long before the appearance of an image, and this image takes the appearance of the plant in its natural living state, not in its dried-up state.

Volckringer patterns differ from the Shroud body image in that they penetrate into the paper, whereas the Shroud image is a surface phenomenon.

The most startling similarity between the Shroud body image and Volckringer patterns is that the latter, like the Shroud, can be reconstructed in 3-D relief using a VP-8 image analyzer. (Fig. 4,5) The intensity of the image is in relation to the distance of the plant material from the paper. In the case of the Shroud, the intensity of the body image is related to the cloth-to-body distance. It should be noted that distances involved in Volckringer pattern formation are quite small.

In summary, Volckringer patterns resemble the Shroud body image in visible spectral reflectance characteristics, UV fluorescence characteristics, detail of image reproduction, negativity and in 3-D reconstruction. The image formation process might also have been operating long after the Shroud was discovered, empty, in the tomb.

My hypothesis is called the "Revised Vaporgraphic-Direct Contact Hypothesis", and involves some parallels to Volckringer patterns. Volckringer patterns are formed when acids are transferred to paper, causing cellulose degradation or modifications of the cellulose molecules, thereby producing an image after a period of time. The image appears because light reflects differently from portions of the paper where cellulose degradation took place.

My theory notes that lactic acid is one of the plant acids involved in Volckringer pattern production on paper. Human perspiration contains a certain amount of this acid, in addition to water, sodium chloride, urea, potassium and other substances. It is likely that a person who had been tortured and crucified would have sweated profusely, producing significantly large amounts of lactic acid. This, then, could have been the transferring agent involved in producing the image on the Shroud.

However, another process must also have been involved in order to produce those parts of the Shroud image located in areas where the body and the Shroud were not touching.

It is possible that the linen was originally stiff, similar to a starched shirt, and that it gradually sagged closer to the body as it became softer in the tomb. This has been proposed by John German, a member of STURP, and would account for how the cloth got close enough to produce a high-resolution image by the vertical diffusion of lactic acid.

I explain the three-dimensional nature of the image as follows: as expected, the lactic acid concentration on the cloth would be less in areas where the cloth was farther from the body, and greater in areas where the cloth was closer to the body. The greater the lactic acid concentration, the more cellulose degradation would occur. Therefore, the intensity of the image produced would vary with the cloth-to-body distance. And, since the cloth-to-body distance would be assumed to be extremely small, a high resolution would result, rather than a blurred image.

However, as stated above, the body image is a surface phenomenon. If the lactic acid theory is correct, why didn't the acid diffuse into the cloth, as is the case with Volckringer patterns? One possible explanation would be that the lactic acid was confined to the surface by the low factor of absorbency of the cloth.

A study done by John Tyrer* for the Manchester (England) Chamber of Commerce Testing House and Laboratories indicates that:

> "The comparatively closely set structure of the linen may not be immediately absorbent of water, let alone the more viscous liquids draining from a corpse. The water stains on the Shroud that were apparently produced in extinguishing

*See Mr. Tyrer's article on page 35.

the Chambery fire do not suggest a high and rapid absorbency." [11]

This may explain why lactic acid was confined to the surface. Then, over a period of time, the lactic acid caused cellulose degradation. The lactic acid was eventually removed, either by washing or by evaporation, so by the time of the 1532 fire, no organic molecules were present on the Shroud. What did remain was only the image, produced by cellulose degradation.

This might also be the answer to why the man's hair leaves an impression on the cloth. In the scalp, the apocrine sweat glands, associated with hair, produce a fatty sweat containing unsaturated fatty acids, urea, lactic acid and other substances. The hair of the man on the Shroud was probably drenched in sweat containing these acids. The evaporation of these acids, or their direct contact with the cloth, would also have produced cellulose degradation after many years.

One additional problem that still needs to be resolved is the uniformity of shading of the Shroud fibers. The straw-yellow fibers all have the same color intensity, yet some areas of the image are more intense than others. The density of the image is determined by the concentration of colored fibers in any given area. A similar example can be seen in the printing of photographs, which are made up of a pattern of tiny dots. The darkness or lightness of the image is caused by the density, or number, of dots used, not by differences in shading between the individual dots.

My hypothesis attempts to resolve a number of previously difficult issues regarding the Shroud image in indicating that two mechanisms might have been involved in producing it: a direct contact process; and a molecular diffusion process wherein lactic acid diffused through short distances to the cloth. The hypothesis is based on the assumption that lactic acid was the substance responsible for the production of the image through cellulose degradation.

In his Gospel, John presents Jesus as the supreme manifestation of God the Father in history and as the mystery-sacrament to accept for one's own salvation. Similar considerations can be made about the Holy Shroud. As Christ is the manifestation of the Father, so the Shroud is the manifestation of Christ, according to a plan of love which we must return in kind and which is concretely expressed by us in faith, hope, and charity.

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