THE TURIN SHROUD BODY IMAGE: THE SCORCH HYPOTHESIS REVISITED

By Thibault Heimburger.

Many years ago the possibility that the body image on the Turin Shroud (TS) could be the result of a light scorch made by a medieval forger had been studied. A hot statue or, better, a bas-relief should have been used. This hypothesis is mainly based on the fact that the body image color is the same as the color of the lightly scorched areas coming from the 1532 fire. The spectra (visible and UV) are also very similar (Gilbert and Gilbert).

Several authors have studied this hypothesis both on theoretical and practical basis and the famous "hot statue" hypothesis was at the heart of the dispute many years ago. Some more or less convincing reproductions of the face of the TS man were made using this technique. For different reasons (mainly to avoid obvious distortions) the only possibility for a forger to create an image resembling that of the TS man face is to use a bas relief (Jackson). However, most of the authors ruled out this hypothesis for different reasons mainly on the basis of macroscopic observations including 3D properties, fluorescence, and lack of superficiality of scorch images or comparison with lightly scorched areas on the Shroud. For a synthesis of the different scorch experiments, see Schwalbe and Rogers.

One of the most important arguments against the scorch is related to UV fluorescence. It is well known that the UV/Vis fluorescence photography of the TS shows that the body image does not fluoresce while the light scorches emit a reddish fluorescence. Miller and Pellicori performed several experiments using the same equipment as in Turin. They concluded: "The scorches associated with the fire of 1532 (…) attest to the rapid combustion of the available oxygen. Their reddish emission is probably due to furfurals, which can be produced under such conditions". These conditions are obviously not the same as those expected for a mediaeval forger. For that reason, the authors made several experiments in open air followed by ageing by baking the samples at 145°C. for 6 hours. They wrote: "linen lightly scorched by a soldering iron in air shows the green-yellow emission, often distributed in plumes of deposited pyrolysis products. We demonstrated in one experiment that the material of the plumes could be transported by water, but the underlying scorched cellulose retained a bright yellow-green fluorescence. This demonstration together with the observed absence of body image fluorescence is strong evidence against the cause for the body image being a scorch". Although we do not know exactly what "lightly scorched linen" means, this demonstration still remains important.

In their 1982 paper, Schwalbe and Rogers concluded regarding the scorch hypothesis : " Because Jackson's studies have shown that three-dimensional hot-statue hypotheses are rather unlikely, we suggest that perhaps an etched or scribed flat-plate may have been used (…) At present, we are aware of no scorching technique that satisfactorily accounts for the observed image density characteristics".

In the following basic experiments, I am not dealing with 3D properties or other aspects of the scorch hypothesis already studied. My goal is much more general: how does a scorch produce a discoloration of the fibers? What are the fundamental properties of the interaction between a hot template and a linen sheet? Are these general properties consistent with the facts seen on the TS?

The linen used is a modern white linen, 1 to 2 millimeters thick, plain weave weaving. These properties are different from the TS but the main conclusions are certainly valid.

FIRST EXPERIMENT

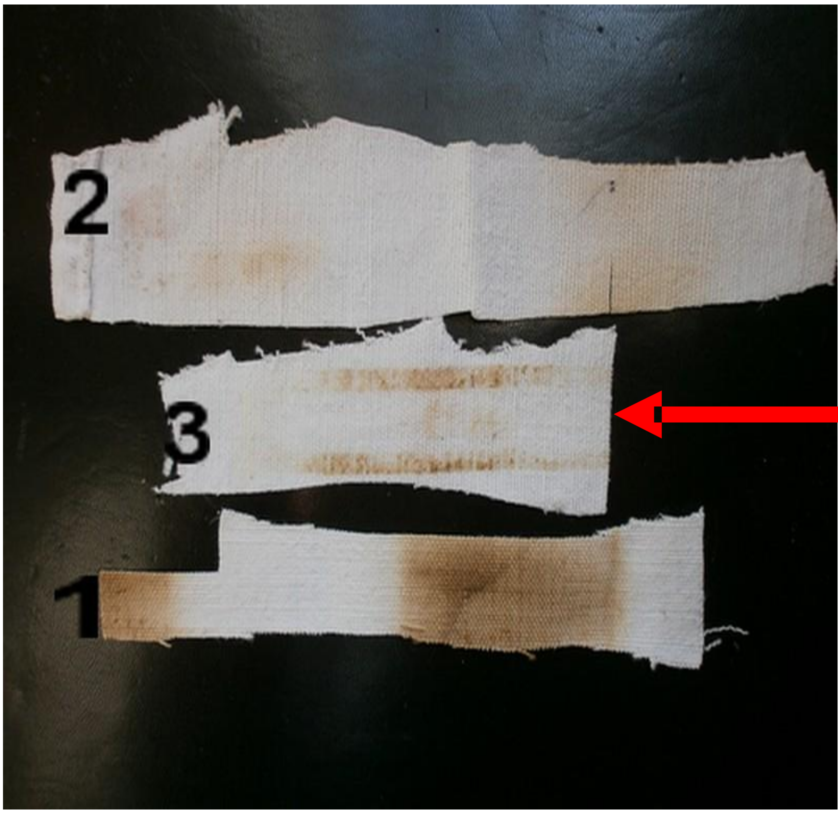

Fig.1: front side (heated)

Fig.3: plate used for sample 3

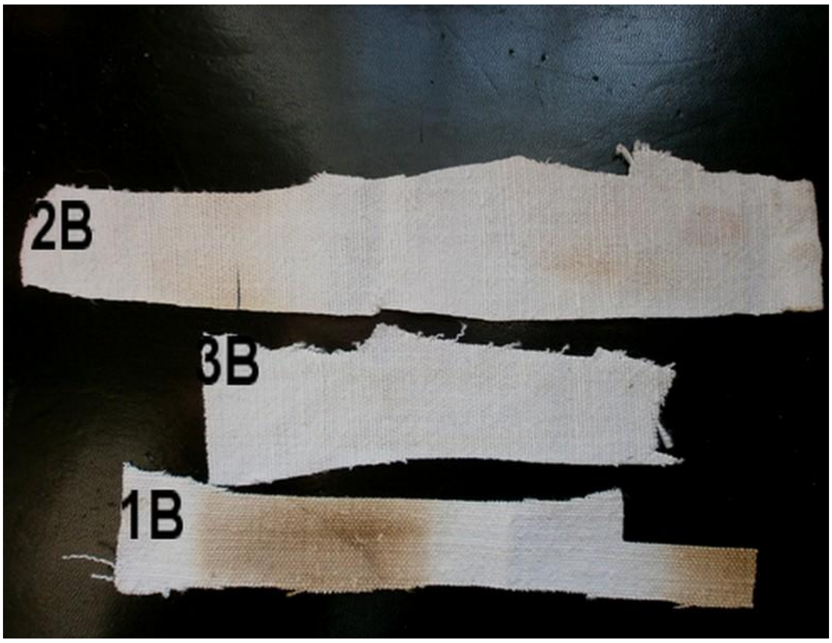

Fig.2: back side

Samples 1 and 2:

In this preliminary experiment, I used a metal hotplate having in its center a rounded small 3 to 4 millimeters deep depression. The temperature (not measured) was everywhere the same at the surface of the plate, including the depression. I applied firmly the linen on the plate.

Bellow a certain temperature no color at all appeared even after several minutes. Above a higher temperature, a color appeared quickly in less than about 10 seconds depending of the temperature. Since it was impossible to look at the heated side when the linen was on the plate, I tried to obtain the lightest discoloration by looking at the backside: I removed the linen as soon as the slightest discoloration appeared on the backside. I got the sample 2. The color on the front (heated) side appears to be a “light scorch” more or less similar to the color of the TS image. What is interesting is the fact that there is absolutely no color in the middle corresponding to the central slight depression.

Sample 1 represents the result of the same kind of experiment but with a higher temperature with a longer contact time between the linen and the hotplate. Again no color is visible in the center.

One can conclude that even with a temperature and contact time much higher than that used by the alleged forger, a true contact is necessary to obtain a color: radiant energy through air does not work.

Sample 3:

Here, I used a hot flat metal plate (Fig.3) with a central flat “band”. This band was a less than 1 millimeter deep depression on one side and a less than 1 millimeter high relief on the other side.

With the central depression put down on the linen, some light to very light yellow scorches appeared in the center, i.e. the central depression (Fig.1, sample 3). Close-up views of these scorches show that the color is made of randomly distributed faint yellow discontinuous patches. The surface of the fabric is not flat. These observations as well as the following observations through a microscope show that the colored fibers are those where a very light contact occurred by chance.

Once again, this demonstrates that a true contact (even low) is absolutely necessary to obtain any discoloration of the fabric.

Another interesting fact comes from the observation of the lack of visible color on the backside of the lateral bands of sample 3 (Fig.2, sample 3B) even if the corresponding areas on the front (heated) side are strongly scorched. This is explained by the fact that I immediately removed the hot plate (contact time less than one second). A superficial discoloration at fabric level can be obtained even at high temperature with a very short contact time because the diffusivity of the cellulose of linen is very low. We will come back to this crucial problem later.

SECOND EXPERIMENT:

In this experiment I only used the plate of Fig.3

The goal was to try to answer to the following question: How could a forger get the shading necessary to obtain an image?

It is clear that the parameters are: the temperature of the hot bas-relief, the contact time and the contact “intensity”. Obviously, a forger could not manage the temperature from point to point on the bas-relief. He could have managed the contact time between the different parts but it is very difficult to imagine. The most probable mean is that the shading came only from different contact intensity or contact pressure. What is interesting here is that this can be obtained naturally by using a bas-relief. If the forger used a uniformly heated bas-relief and applied a linen on it, it is possible to have a contact everywhere (necessary condition). Naturally, the contact in the flat areas or small depressions of the bas-relief would be light while the contact with higher areas (like the nose) would be more intense.

The following experiment is a model experiment built to observe the macroscopic and microscopic characteristics of an “image” obtained that way.

First (Fig.4), I applied the heated plate with the central slightly depressed band down on the linen lying on a flat surface (contact time: 3-4 seconds). While the temperature was about the same everywhere, I did so that the contact was much more intense in the upper part than in the lower part of the photograph shown in Fig. 4. As expected, the lower part shows a very faint yellowish discoloration and the upper part a yellow brown discoloration. Most of the microphotographs showed bellow come from this sample. I will call in the following:

- Very light scorch (VLS): the areas with a color at the limit of visibility, coming from the central band or the lowest part of the lateral bands (very slight contact).

- Light scorch (LS): the areas with a yellow color (slight contact)

- Scorch (S): uniform yellow-brown colored area (strong contact)

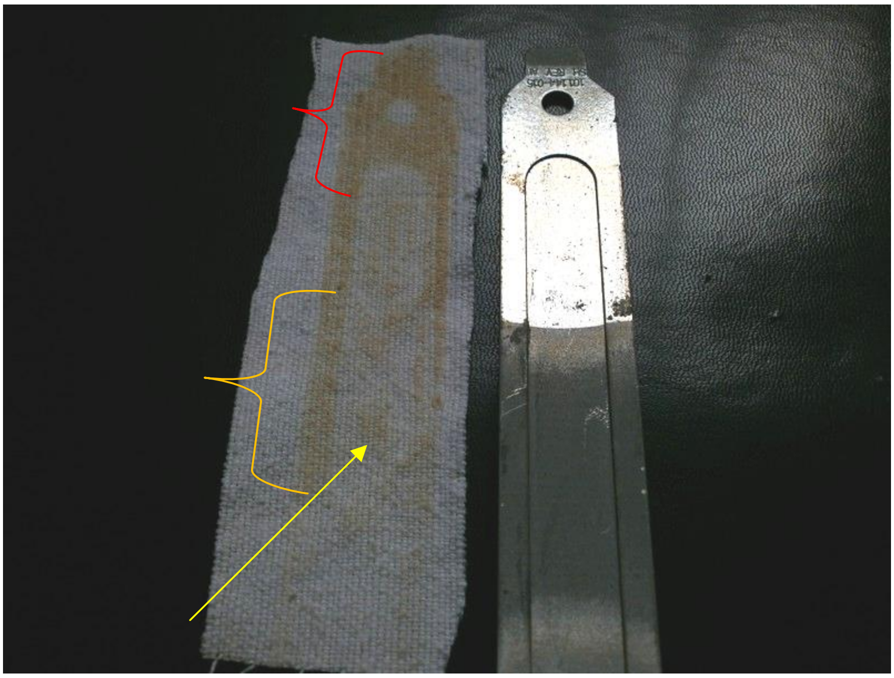

Fig.4. Yellow arrow: very light scorch (VLS). Orange brace: light scorch (LS). Red brace: scorch (S).

Fig.5: central relief (<1 millimeter) down. Strong contact pressure. Different temperatures.

Fig.6: backside of Fig.5

In the second set of experiments (above), I put down onto the linen the other side of the plate, this one having a less than 1 millimeter high relief (the opposite of the previous test). The linen was on a pillow in order to obtain the best possible contact. Contact pressure is roughly the same but now the temperature and the contact time are different.

This last experiment shows how difficult it is to manage the temperature to obtain something resembling the TS image shading. On the image on the right, the lateral bands have the right yellow color but the color of the central relief is too brown. The image on the left shows the correct yellow color for the central relief but the lateral bands have no color at all.

In other words, even with a less than 1 millimeter high relief, either the relief has the right color and the neighboring areas have no color either the neighboring areas have the right color and the relief is much too colored.

This problem of contrast has already been discovered by Jackson. He wrote: “Another difficulty lies in image contrast. The maximum shading of the Figure 21 [note: a heated medallion] and figure 22-A full-size bas-relief image was much greater than the Shroud, approaching a deep brown scorch. This high intensity of shading at contact points was necessary in order for the more distant parts of the bas-relief to record their patterns on the cloth (...). It thus appears as though linen has a thermal response such that exceedingly low bas-reliefs are necessary to produce an image with an overall contrast variation as subtle as on the Shroud. The construction of such a relief may pose significant technical problems for a hypothetical craftsman; we note that our bas-relief was 1 cm thick at the maximum (nose to background) and the medallion relief was considerably lower, on the order of a millimeter. We also constructed a thicker bas-relief (2.2 cm thick) and observed that the contrast problem was more pronounced”. This is exactly what I found.

Incidentally, Jackson found that using a wet linen rather than a dry linen produced a non uniform image with very bad 3D characteristics.

Since the only sample showing more or less the characteristics of the Shroud is that of the Fig.4, we will use it for the observations with the microscope.

MACROSCOPIC OBSERVATIONS (CLOSE UP):

 Slightly contrast enhanced	VERY LIGHT SCORCH Very low contact Limit of visibility Color : pale yellow Non uniform: many uncolored threads in colored areas and many areas without color (“patches”).

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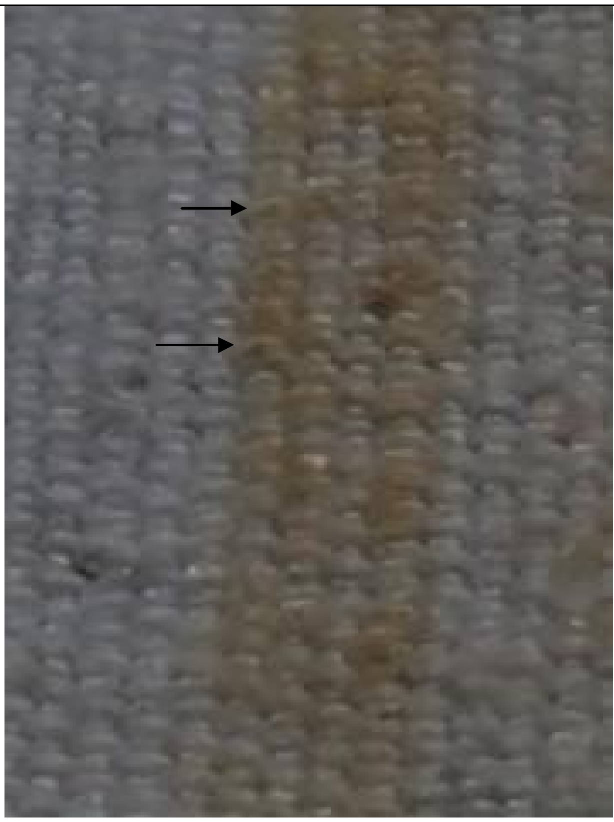
<td></td>
<td>LIGHT SCORCH

Low contact

Color : yellow to pale brown

More uniform: majority of colored threads, although some non colored threads are present.

Brown « hot spots » on top of many colored threads (arrows)</td>
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<tr>
<td></td>
<td>SCORCH

Heavy contact

Color : dark yellow to red brown

Homogeneous distribution</td>
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OBSERVATIONS THROUGH THE MICROSCOPE

Very Light scorches (VLS) :

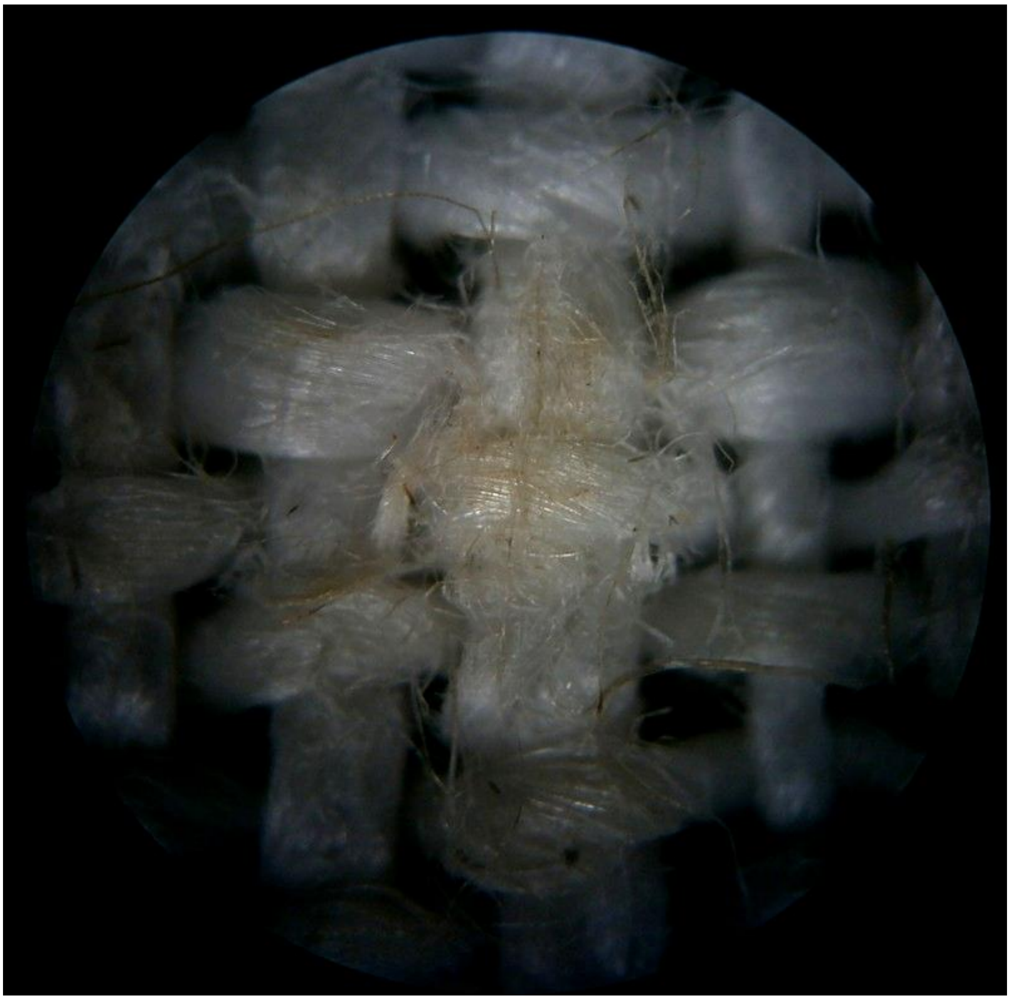

Fig.7 : Typical Very Light Scorch

Most of the threads have no or almost no color. Yellow translucent fibers are found only in limited areas on the highest parts of few threads. Some brown to dark (burned) protruding fibers are visible (see also Fig.8 bellow).

At thread level, the VLS seems to be superficial and no color is visible on the backside (Fig.9 and 10)

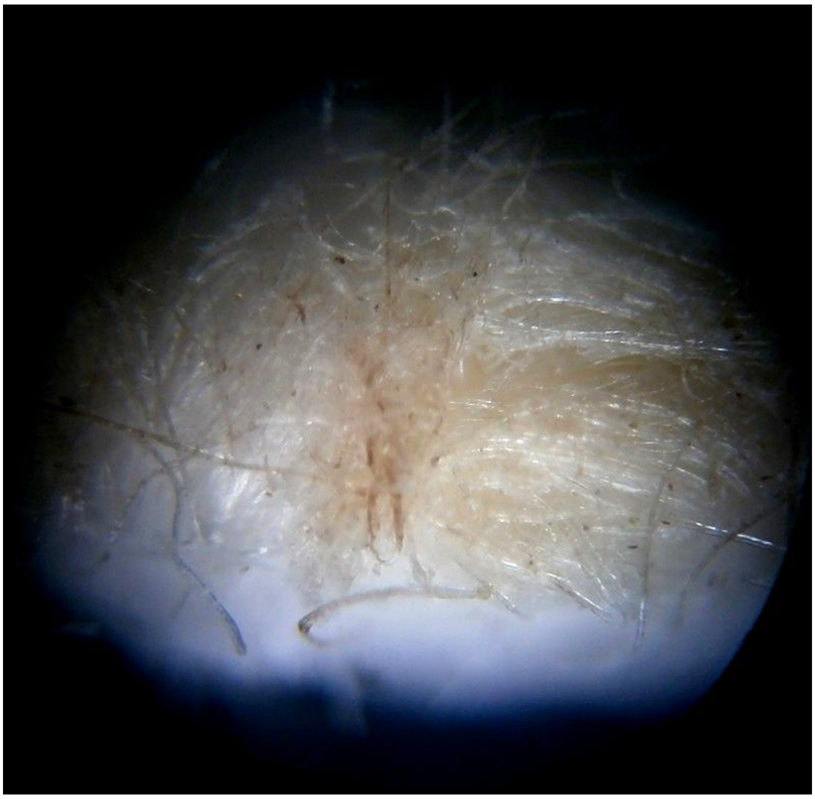

Fig.8: Very light Scorch. Highly colored portions of some superficial fibers

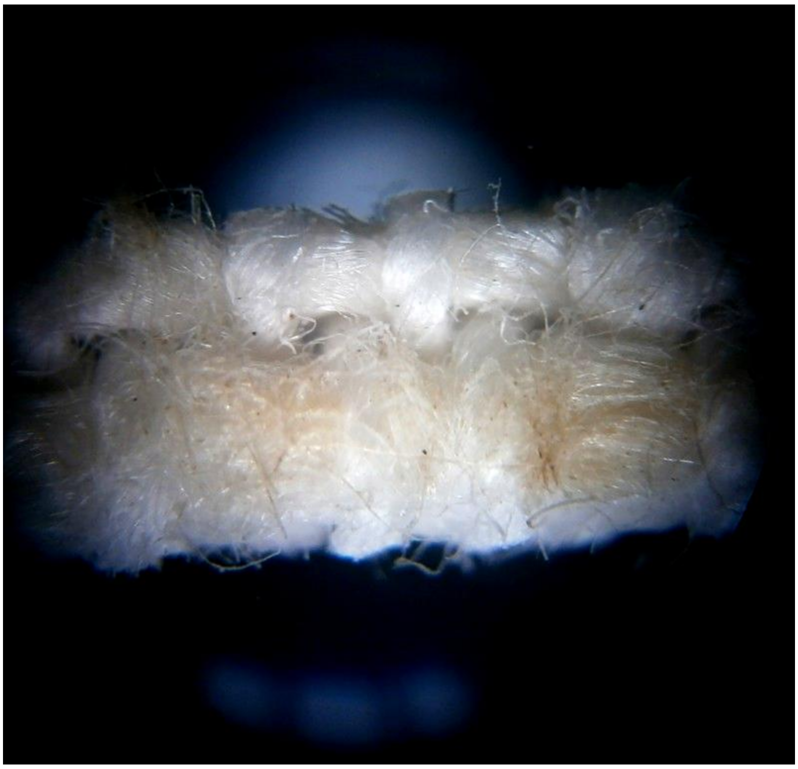

Fig.9: Very Light Scorch. Thread: heated side.

Fig.10: Very Light Scorch. Backside of the colored thread of Fig.9.

Light Scorch

Fig.11: Light Scorch. Typical view. Low magnification.

Fig.12: Light Scorch. High magnification.

Fig.13: Light Scorch. “Micro hot spot” (arrow).

Fig.14: Light Scorch. Burnt fibers.

Here the majority of the threads are colored. The color distribution is more uniform although it remains often limited to the upper part of the threads.

Most importantly, the color tends to become light brown to brown in the most superficial parts of the colored threads. In some areas “micro hot spots” (Fig.13) and even burnt fibers (Fig.14) can be found.

It is important to recall here that the (low) temperature was the same as in the very light scorch areas, the only difference being the contact intensity or pressure and absolutely no burn can be seen with unaided eyes in this experiment.

Contrary to the very light scorch, the light scorch is not superficial at fabric level and thread level (Fig. 15 and Fig.16).

Fig. 15: cut in a lightly scorched area. The entire thickness of the colored threads is colored.

Fig.16: Light scorch. Slightly colored portion (left) versus colorless portion (right).

Scorch

Fig.17 (above, right part) and Fig.18 (bellow): scorched areas (low magnification).

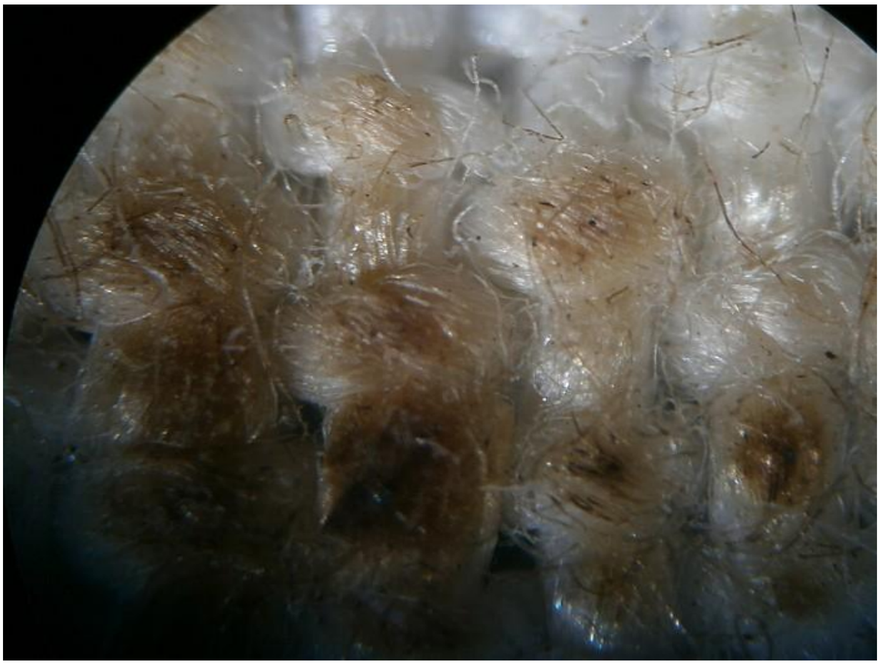

Fig.19: Scorch. High magnification.

All the threads are colored and on many threads the entire length of the exposed fibers is colored. However a color gradient is obvious from dark brown at the top of many threads to yellow at distance of the heavy contact points. Burned fibers are easily found in the highest parts of most threads and as protruding free fibers.

COMPARISON WITH MICROPHOTOGRAPHS OF BODY IMAGE AREAS ON THE TURIN SHROUD

Fig.20. TS image area. Low magnification. © 1978 Mark Evans collection, STERA, Inc.

Fig.21. TS image area. © 1978 Mark Evans collection, STERA, Inc.

Fig.22. TS image area. High magnification. © 1978 Mark Evans collection, STERA, Inc.

Fig.23. TS image area. Very high magnification. © 1978 Mark Evans collection, STERA, Inc.

The above TS photographs come from different parts of the image-only areas. The characteristics of the image are the same everywhere (except the color density). One must be cautious in interpreting these photographs: the overexposed small bright spots hide the underlying color.

The most obvious and well known characteristics are the following:

- All the threads (warp and weft) are more or less colored even if the color is generally denser on the warp threads (the horizontal threads in the above pictures) which are generally higher than the weft threads with respect to the fabric plane.

- The color is not limited to the uppermost portions of the threads (this sentence is frequently misunderstood). In many cases, the color can be followed even on the oblique downward portions of the threads.

- There is no color gradient between the horizontal and the oblique downward portions of any colored thread.

- Striation is obvious: the general pattern of the color tends to follow the direction of the fibers. In addition some more colored bundles of fibers are adjacent to less colored fibers.

- At high magnification absolutely no burned fiber (even for the protruding free fibers) is seen.

HIGH MAGNIFICATION MICROSCOPIC OBSERVATIONS OF INDIVIDUAL FIBERS COMING FROM THE SCORCH EXPERIMENTS

For these experiments I tried to separate individual fibers with a needle and also applied a sticky tape at the surface of colored areas.

It quickly appeared that colored fibers, even in light scorched areas, are very brittle and often broken. In addition in very light and light scorched areas, very few yellow colored fibers are found.

The main important result is that in all areas, including very light scorched areas, many tiny portions of brown opaque fibers are easily visible. This was never described by McCrone or by STURP researchers on the 1978 sticky tapes. This is the signature of a scorch and this would have been immediately recognized.

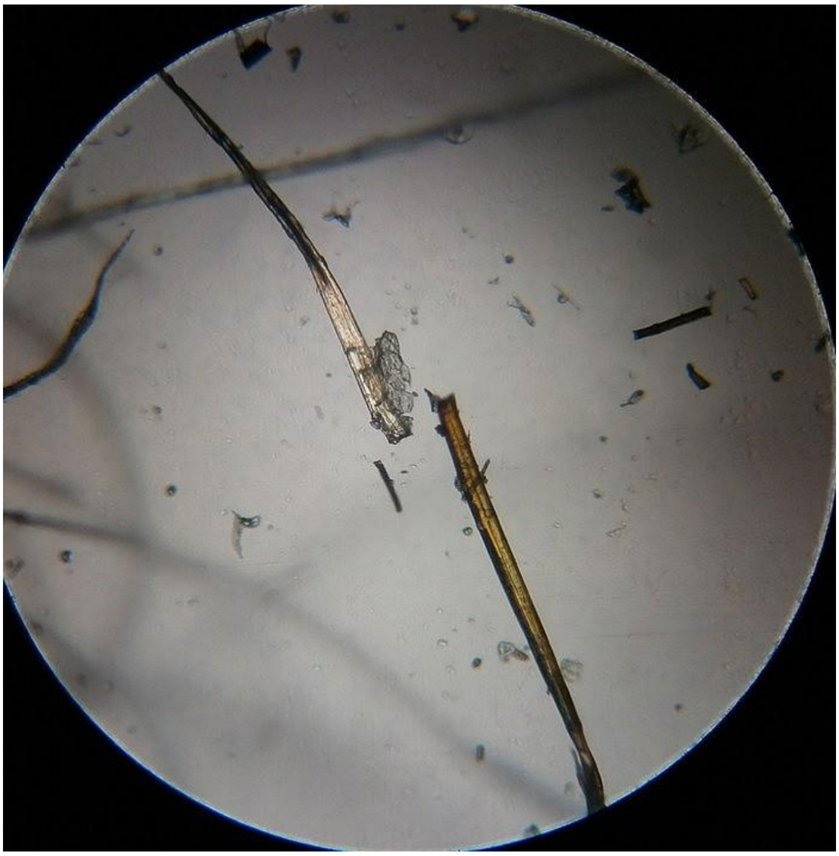

Fig.24: Light Scorch. Colored fiber (with colored medulla?) and colorless fiber

Fig.25. Light Scorch. Colorless, yellow and orange fibers, burned fiber

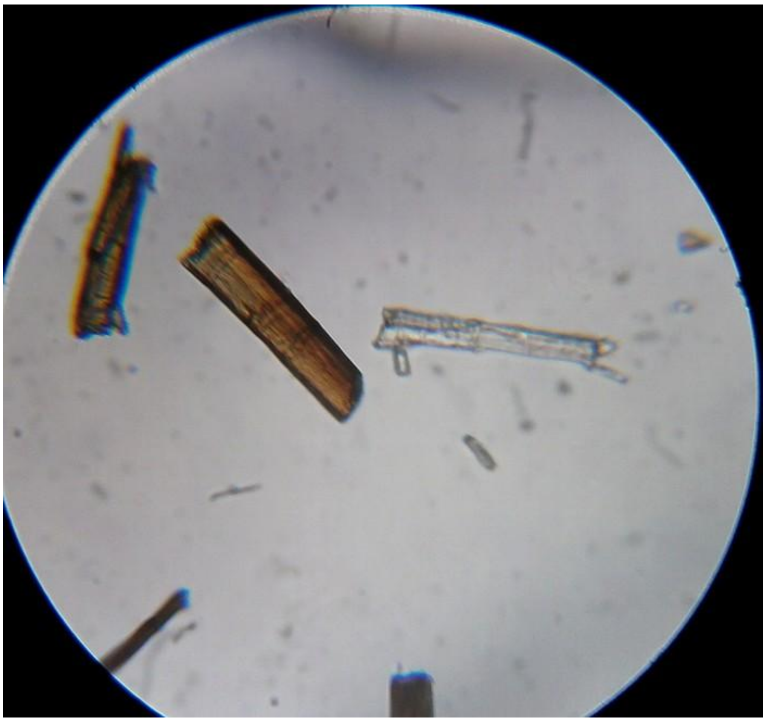

Fig.26. Light scorch. One of the many red-brown tiny broken pieces of fibers.

In order to see several relatively long pale yellow portions of fibers similar to the TS image fiber, I had to apply a sticky tape on a heavy scorched area (Fig.27). The entire range of color, from colorless to opaque dark burned fibers is seen. Only a very narrow range of temperature is able to give pale yellow translucent fibers by thermal diffusion.

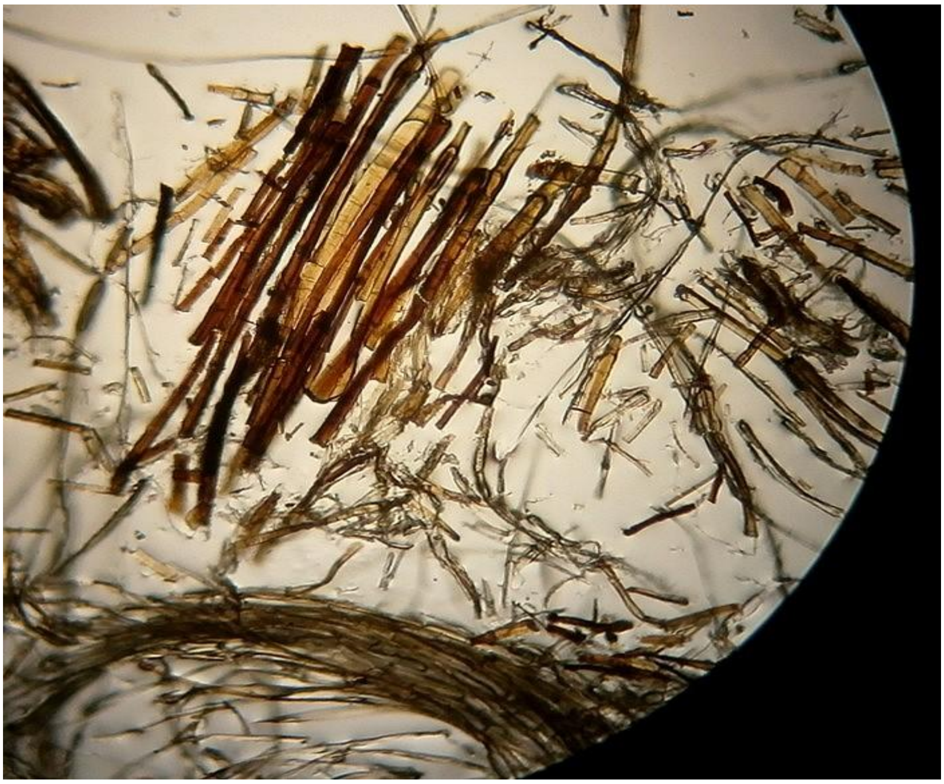

Fig.27. Heavy scorch. Many colorless, brown and dark fibers visible. Few pale yellow fibers are seen.

SYNTHESIS

VLS = Very Light Scorch. LS= Light Scorch. S= Scorch (See p.6-7)

	TURIN SHROUD	SCORCH EXPERIMENTS	COMMENTS
Continuity of the colored areas (low magnification)	Yes: all the threads are (more or less) colored	VLS: No* LS: more** S: yes***	* only very few colored threads ** about 50-70 % colored threads *** about 90%-100% colored threads
Color	Pale yellow everywhere Translucent fibers No color gradient at the surface of the thread	VLS: idem TS, gradient LS: light brown* to pale yellow**, gradient S: deep brown or black* to pale yellow**, gradient	Gradient: * highest horizontal portions of threads ** at distance of the highest horizontal portions of the threads
Striation	Yes Bundles of more colored fibers	No No	
Burned fibers	none	VLS, LS : some S: many	
Micro hot points	No	Yes (mainly on LS and S)	
Superficiality	Extreme	VLS: superficial LS and S : no	

	TURIN SHROUD	SCORCH EXPERIMENTS	COMMENTS
Sticky tape	Intact pale yellow fibers No orange to dark portions of fibers	VLS, LS : no or little intact pale yellow fiber VLS, LS : many orange to brown to dark small portions of fibers	

DISCUSSION AND CONCLUSION:

The fundamental mechanisms involved in color production by any kind of scorch are clear. At a given temperature above a certain threshold, the color of the portions of fibers in narrow contact with the hot material immediately begins to change. In the same time, the heat propagates along the fiber and, probably, between adjacent fibers. But the key parameter is the very low diffusivity of linen: there is a steep color gradient. In this sense, scorching can be seen as an almost perfect "contact-only" image formation process. No contact, no color.

The Turin shroud image is continuous: on the face, all the anatomical parts are seen, including for example the sides of the nostrils. There is no "hole" (taking into account the "banding effect"). Of course the lack of image in some areas (the areas surrounding the hands for instance) does not prove that the TS image is a contact-only image. Thus, a forger using the scorching technique would have to put the linen in contact with all the parts of the bas-relief.

The color of the TS image fibers is everywhere the same: a pale yellow. This does correspond to what I called a very light or a light scorch. This is obtained on a small surface at low temperature.

At thread level, the TS image color distribution is continuous: all the threads are colored. Because the scorch mechanism is a contact-only mechanism, this can only be obtained by an intimate contact, i.e. a relatively high contact pressure.

Consequently, in theory, in order to obtain an image resembling the TS image, a forger would have to use a bas-relief, to heat it uniformly in a narrow range of low temperature, to apply it firmly on all parts of the bas-relief and to control the contact pressure and the contact-time.

Let's assume that after some trials, he would have succeeded in this task. Even in this case the above table shows the fundamental differences with the TS image characteristics as seen through the microscope.

The main arguments ruling out the scorch hypothesis can be summarized as follows:

- It is simply impossible to obtain an "image" made only of pale yellow fibers.

- A color gradient between the horizontal highest part and the oblique lateral parts of the threads is always observed and particularly obvious in very light and light scorched areas.

- If on a given flat area a faint yellow superficial color can be obtained, the color distribution does not match that of the TS image: most of the threads are colorless and the gradient at thread level is obvious. Applying a higher contact pressure result in a color distribution more uniform (more threads are colored), a less obvious gradient (although detectable) and finally an image distribution that is more similar to that of the TS image, although clearly different. But in this case, several fibers at the topmost parts of these threads are burned. A higher contact pressure is the only way to obtain shading. Even with a one millimeter high relief (the nose for instance), the contrast with the adjacent parts is much too high with respect to the TS image (as shown by Jackson) and this fact is explained by the observations through the microscope.

- the consequence is that a light scorch does not show truly the halftone effect observed on the TS image: in the more colored areas, shading is not obtained by a higher density of only pale yellowed fibers, but by a higher density of more colored fibers, with a wide range of colors: from brown-dark burned fibers to few pale yellow fibers with the gradient described above.

- No striation or bundles of more colored fibers are seen in any scorched areas.

- The "signature" of a scorch is found in all kind of scorches, even in very light and light scorches: even at the lowest temperature, some protruding burned fibers are observed and many small opaque brown to dark burned pieces of fibers are easily found everywhere in the sticky-tape experiments. This was not the case for the direct observations with the microscope on the Shroud in 1978 or on the sticky-tapes.

All these differences are related to the fundamental properties of color distribution resulting from the scorching of any linen fabric, i.e. the fact that a scorch is a contact-only mechanism associated with the very low heat conductivity of linen and the spatial geometry of the fabric. This is inevitable.

The TS image is not a scorch, even a light scorch. In fact, this old hypothesis is very easy to rule out definitively as the body image formation mechanism with some basic experiments and a microscope.

<u>References</u>:

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