IV Symposium Scientifique International du CIELT
Paris, 25-26 Avril 2002

Bloodstains characteristics to be considered in laboratory reconstruction of the Turin Shroud

Carlo Brillante*, Giulio Fanti°, Emanuela Marinelli[+]

* Chemistry and Clinical Microscopy, University of Bologna
Via Amendola 11, 40121 Bologna – Italy – Phone 051-254418

° Department of Mechanical Engineering, University of Padua, Via Venezia 1, 35137 Padua - Italy
Phone: +39-049-8276804, fax +39-049-8276785, e-mail: <giulio.fanti@unipd.it>

[+]Collegamento pro Sindone, Via dei Brusati 84, 00163 Rome - Italy
Phone & fax: +39-06-66160914, e-mail: <cpshroud@tin.it>.

SUMMARY

This paper considers the characteristics of the "red stains" detected on the Turin Shroud that, from a bibliographic analysis, are bloodstains of two different types: the blood that came out when the man was still alive and the blood that came out after the death.

Many peculiar characteristics of the bloodstains are highlighted, such as the fibrinolysis process, that must be taken into account for anyone who wants to reproduce the Shroud.

There are finally listed all the operations necessary for an hypothetical artist to obtain a result comparable with that of the Shroud. It is then highlighted how it is difficult, even more for an hypothetical medieval forger, to "build" a copy of the Shroud only from a bloodstain point of view.

1) INTRODUCTION

The Turin Shroud (TS) is a linen sheet 4.37 m long and 1.11 m large[1] that bears the image of a scourged, crowned with thorns and crucified man. There are also impressed many marks due to blood, fire, water and folding that partially disturb the observation of the double body image (front and back).

The image is composed of a front image 1.95 m long and a back image 2.02 m long, separated from the former by a non-image zone of 0.18 m.

After scientific analysis of the TS in 1978, the STURP[2] (Shroud of TUrin Research Project) concluded that the body image on it cannot be explained scientifically, and that a likely explanation consists of stating that the image formed as if it was caused by exposure to a short-lived but intense source of energy coming from the body covered by the TS itself.

The body image: is extremely superficial; was chemically caused by oxidation and dehydration of the cellulose fiber; is yellow in color; has chromatic uniformity; has three-dimensional (3D) features.

Individual 10 to 20 micrometer diameter fibers, on the tops of the linen threads, are darkened in random places to produce the image. This has been likened to a random halftone process, but there is no ink or dye, only dehydrated cellulose provides the chromophore. In darker areas of the image there are more of these random elements. That hypothesized particle radiation struck the individual fibers. The resulting body image is shown by the VP-8 scanning densitometer[3] to have the proper anatomical shape, unlike a reflected light image we normally see with our eyes.

Still another feature of this image is that it does not fluoresce when exposed to ultraviolet light, as would a scorch.

The bloodstains, transposed to the linen fabric by fibrinolysis, were impressed on the TS before the body image formed, since there is no body image under them. The processes of redissolving and transposition of blood in a damp environment may occur after a period of at least 3-4 hours; the body of the Man remained in the TS for less than 40 hours, because no signs of putrefaction can be found.

Many experimental tests have been carried out on linen fabrics in order to obtain results empirically similar to those of the body image of the TS. Although good experimental results have been obtained, in the sense that, at first sight, the image of the face is similar to that of the TS Man, until now no experimental test has been able to reproduce all the qualities found in the image impressed on the TS.

The Man of the TS was not completely in a supine position but, according to the *rigor mortis*, had his head tilted forwards[4], his knees slightly bent, and his feet extended as a result of nailing.

The hypothesis, now practically accepted by the entire scientific world, is that the image is not a painting, since the scientists of the STURP showed the absence of paint pigments in quantities sufficient to explain the presence of an image[5, 6]. However, some doubts remain regarding the characteristics of the Man who was enveloped in the TS. Some distortions in the body image are evident, e.g., points corresponding to the hands and calves, which exclude any kind of photographic procedure used to obtain the image.

Over the past 100 years scientific study of the TS has shown the body image is unique to the point that it cannot be duplicated even nowadays. The mechanism of image formation has not yet been explained scientifically. Some researchers proposed experimental techniques to reproduce the TS image and many of them have drawn near the objective; however, they did not reach the goal of satisfying completely all the characteristics of the TS image, discovered with very refined analysis.

This paper does not discuss the technical impossibility to build a body image satisfying all the characteristics detected (this discussion can be found in a different paper[6]). It evidences that the difficulties to reproduce the bloodstains must be added to those detected to reproduce the body image.

The goal of the present paper, that considers only the blood traces, is therefore double:

a) to show that the TS copies coming from various experiments does not reproduce the characteristics of the bloodstains detected on the TS;

b) to list the typical characteristics that a laboratory copy of the TS should have from a bloodstains point of view.

2) CHARACTERISTICS OF THE SHROUD

The body image of the TS shows physical and chemical characteristics that present science is not able to explain; some of them are widely discussed in a different paper[6].

a) *From a physical and chemical point of view:* the body image is chemically due to a molecular change of the cloth cellulose; it is stable; there are no cementation signs and no pigment; it is extremely superficial; it does not fluoresce; it is yellow in color and has chromatic uniformity; it directly corresponds to a body enveloped in the sheet; it does not evidence putrefaction signs; it shows a different tensile strength.

b) *From an optical point of view:* the body image has three-dimensional features; it is well resolved but edges are not well defined; the maximum luminance level of the front and back images (face excluded) are compatible within an uncertainty of 5%; the maximum luminance level of the head image is higher of more than 10 % with respect to the luminance of the body image; side images are missing; the body image is generally coherent with a vertical projection and it is non-directional, but some distortions due to enveloping are evident in correspondence of the hands, shoulders and calves; the color of the image-areas has a discontinuous distribution on the entire facing surface[7].

It is obviously difficult, if not impossible, to make a laboratory copy of the TS that satisfies all the characteristics evidenced, but some researchers proposed many hypotheses of image formation and carried out many experimental tests[6]. The most interesting hypotheses are: artist intervention such as painting, modified carbon-dust technique or a technique involving a bas-relief, diffusion mechanism, direct contact, natural radiation source or mixed mechanisms, but they cannot contemporarily satisfy all the peculiar characteristic detected.

On the other hand, the hypothesis of the radiation source coming from within the body can satisfy all the characteristics even if two problems arise. The first is that no experimental test has been done to completely confirm the hypothesis; the second is that the hypothesis goes out of the traditional science because a miracle related to Resurrection is involved.

3) STUDY OF THE SHROUD RED STAINS

In this work only the red marks that are evident on the TS are deeply taken into consideration because different researchers very often consider them only marginally.

Some scholars, in fact, declare that they succeeded in obtaining results completely correspondent to the TS imprints only because they don't consider the different particular characteristics of such imprints deeply enough.

Figure 1 shows some groups of red stains; Figure 2 the scourging strokes on the legs; Figure 3 the details of the side wound, of the blood flow on the right forearm, of the wound due to a nail in the left wrist; Figure 4 the blood from the side wound; Figure 5 two macro-photographs; Figure 6 the blood on the head caused by the crown of thorns.

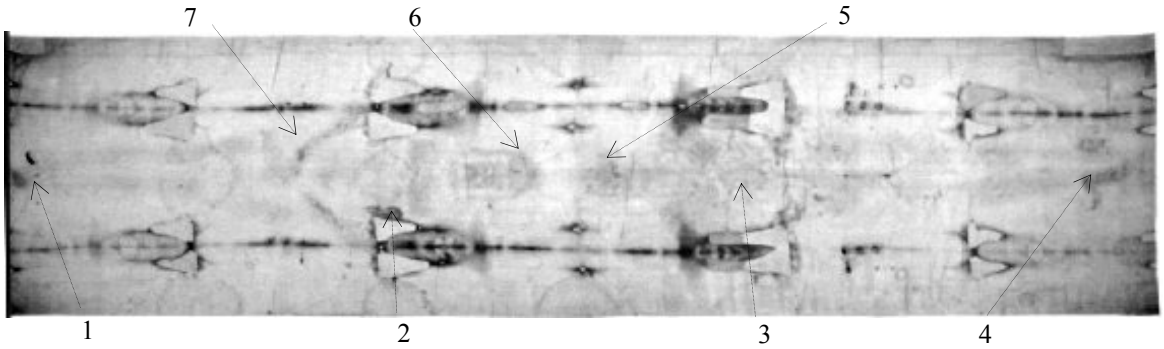

Figure 1: Body image and red marks visible on the TS recognized as: 1. Wound of the right foot. 2. Side wound. 3. Scourging strokes. 4. Heel and sole of the right foot. 5. Wounds on the head, due to the crown of thorns. 6. Wound on the forehead, due to the crown of thorns. 7. Wound of the left wrist.

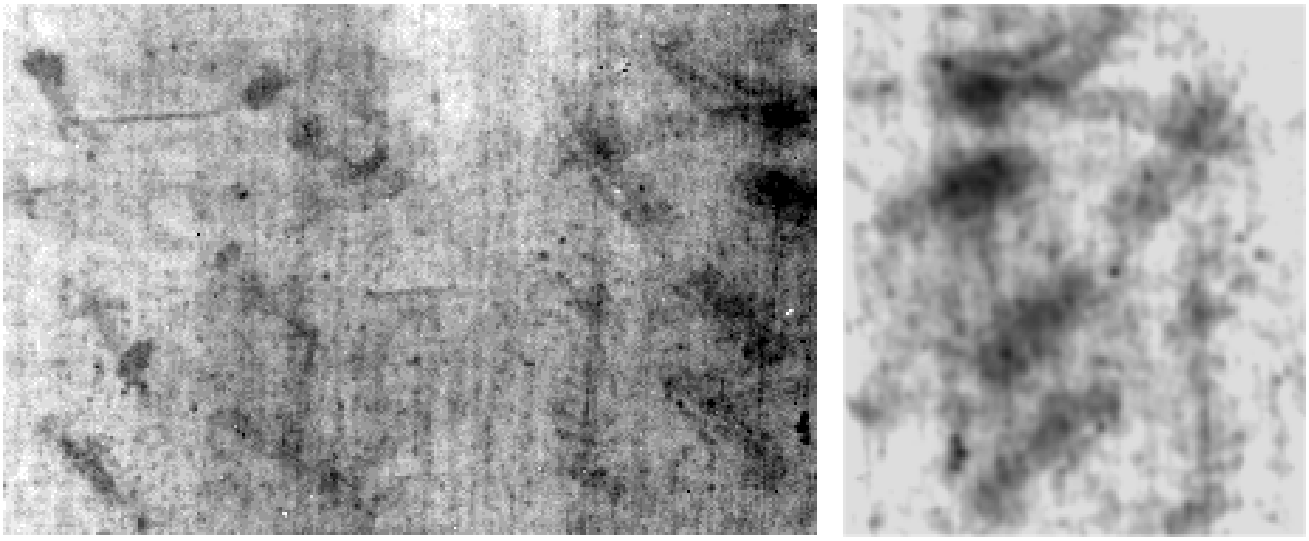

Figure 2: Scourging strokes on the legs (back image) taken from Enrie plates.

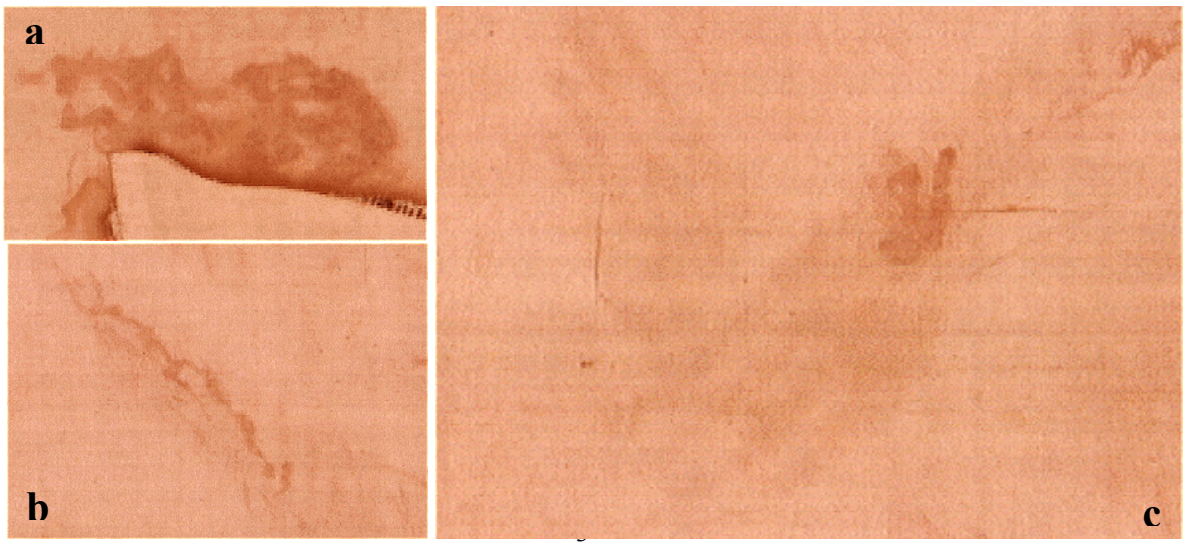

Figure 3: The details recognized as: a) the side wound; b) the blood flow on the right forearm; c) the wound due to a nail in the left wrist, taken from B. Schwortz photographs.

In 1973 the first analysis of the red stains present on the TS was carried out by G. Frache et al.[8] Their tests, performed on exiguous material, produced negative results. Nevertheless they concluded: "The negative answer given by the investigations we carried out does **not** permit us to make an **absolute** judgment of exclusion of the hematic nature of the material under examination".

In 1978 new analyses were performed independently by P. Baima Bollone in Italy and by J. H. Heller and A. D. Adler in USA.

Heller and Adler[9] were well aware that false negative conclusions can be drawn if the material cannot be adequately solubilized, as can occur with a very aged strongly denatured sample (it was the case of the 1973 analyses). Therefore, they chose to use the conversion of the suspected heme group to a porphyrin, detectable by its characteristic Soret band excitable red fluorescence, as a very specific test (the Soret band is a very strong absorption due to the heme porphyrin at four hundred and ten nanometers[10]). They obtained positive results.

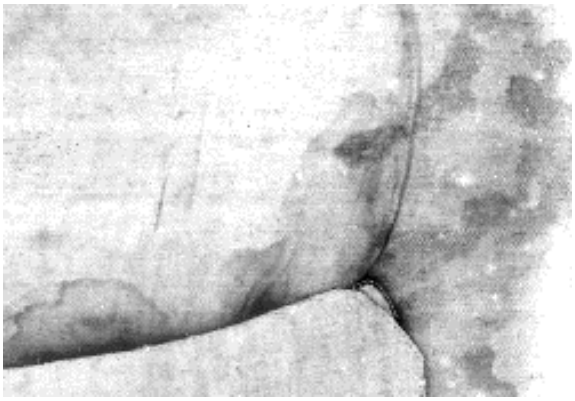

Figure 4: Blood from the side wound (back image), taken from Enrie plates.

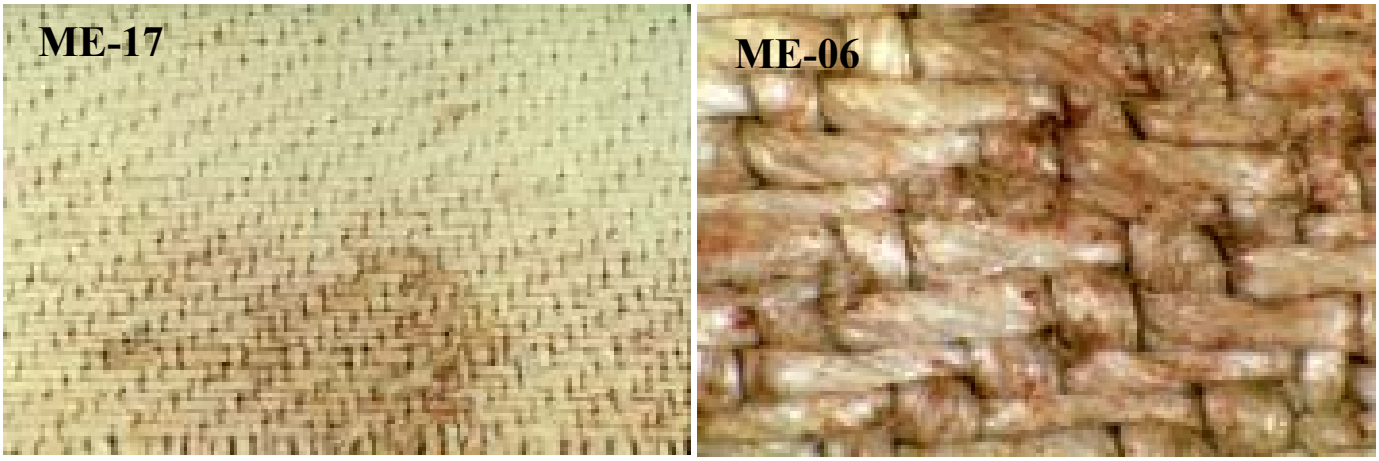

Figure 5: two macro-photographs made by Mark Evans, kindly furnished by Barrie Schwortz: ME-17 corresponds to a dorsal foot (6.3x magnification) and ME-06 corresponds to the dense blood of the back (32x magnification).

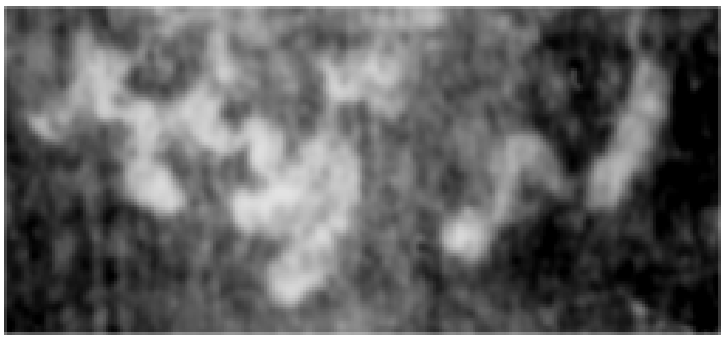

Figure 6: Blood on the head, caused by the crown of thorns (back image), taken from Enrie plates.

In addition to the heme derivative, Heller and Adler[11] found on the TS bile pigments and serum type proteins (albumin), indication that on the cloth there is whole blood and not just heme protein; they found also serum haloes at the margins of blood clots and concluded that the TS was in contact with a wounded human body. A solution of proteolytic enzymes completely dissolved the red particulate coating the fibrils, leaving no particulate residues. This further indicates that this particulate is blood. This protease treatment also removes the golden yellow coating of the serum coated fibrils, corroborating its identification as serum. Interestingly, fibrils freed of their coatings using this technique closely resemble the non-image fibrils when viewed under phase contrast microscope. This is a strong indication that the blood and the serum coated the fibrils before the image formation and "protected" the fibrils when the image was forming.

Heller and Adler rejected, with exhaustive explications, the microscopic evaluation of the TS samples provided by W. C. McCrone[12], who claimed that the body image is due to an iron oxide earth pigment bound with an age yellowed animal protein binder that had been painted onto the cloth and that the blood marks are a mixture of iron oxide pigments and vermillion in this same binder. McCrone insisted with his objections[13], but had again a complete rebuttal by David Ford[14], who demonstrated also the contradictions of McCrone about the size, shape and color of iron oxide, mercury sulfide and TS particles.

Baima Bollone demonstrated that on the TS there is blood[15], that is human blood[16] and of AB group[17].

From these results the authors are convinced that the red stains are human bloodstains and therefore the "red stains" will be called "bloodstains" in the following paragraphs.

4) CHARACTERISTICS OF THE BLOODSTAINS

4.1) TYPES OF BLOOD

The bloodstains on the TS are of two different types that must be taken into account for any reproduction of the TS:

1) the blood that came out when the Man was **still alive,** such as that of scourging (Figure 2) and of crown of thorns wounds or wrists wounds (Figure 3b and c);

2) the blood that came out **after the death** such as that of feet wounds or side wound with blood separation in a dense part and a serous part (Figure 2a, 4 and 5).

Due to the Chambéry fire of 1532, near the mending done by Chambéry Clare nuns after the fire, **burnt** blood was also detected as result of a source of heat.

The **coagulation** on the skin and the **transposition** on the cloth of type 1 **blood** has the following stages:

a) **Clot formation**: it is a complex biological mechanism that changes liquid blood into a solid, soft, moist jelly-like substance in 5-10 minutes. The clot is formed because the fibrinogen, a substance dissolved in the blood, changes into a solid substance, the fibrin, that traps in its meshes the red cells.

b) **Clot retraction**: the clot retracts and exudes its liquid part, the serum (a clear yellow fluid) in 20-45 minutes.

c) **Clot drying**: the clot loses its moisture and becomes hard and crust-like. The time in which this takes place is dependent on physical factors such as clot size, temperature, air currents, moisture, etc. P. Barbet[18]

noted that the TS blood has the aspect of blood clots formed on the skin. Those blood clots have a pale internal zone, sharp and evident edges and a pale halo of serum; are depressed in the centers, raised on the edges. Lavoie[19] added that the clots did form on the body of a man who died in the position of crucifixion.

d) **Clot redissolving and bloodstain formation**: this process is responsible of the bloodstains formation on the TS. In Barbet's opinion, it was sufficient a damp atmosphere to moisten the clots, but the fibrinolysis[20] (fibrin's liquefaction) played an important role in the transferring of the clots on the TS. The coagulating and fibrinolytic systems are in a dynamic equilibrium between them. The first one forms the fibrin, the second one removes it. The phenomenon of the lysis must have happened in a relatively short time, from 3-4 hours after death and in any case not more than 24-36 hours after death. The fibrinolytic phenomenon follows definite laws according to the period of contact. If this does not exceed a certain amount of hours the transfer does not take place, or takes place in a rudimentary manner; while, if it exceeds that number of hours, the blood will smear the fabric (and therefore it will not form a transfer) because of the increased friability of the blood clots. This is one of the fundamental observations that confirm the undeniable relationships between the fibrinolysis and the hematic stains on the TS. The TS shows that the fibrinolysis had started and ceased at an unknown time, probably not more than 36-40 hours, because of the contact end between the body and the TS, since the hematic traces are perfectly transferred and delineated.

e) **Clot redrying**: finally the bloodstains, transposed on the cloth by means of the fibrinolysis process, dry on the TS.

4.2) THE BLOOD REDNESS

About the maintenance of the red color of the TS blood with time, contrary to what asserted by C. Goldoni et al.[21], an important role was ascribed by Adler to the extraordinarily high bilirubin content[22].

P. L. Baima Bollone et al.[23] consider likely that in the blood of a man who suffered many traumas and wounds a high amount of bilirubin is formed. According to them, the existence of a very high amount of bilirubin in the TS bloodstains could explain the red bright color of the bloodstains, even if this color is not directly due to the bilirubin but to the carboxyhemoglobin.

From these results, the explanation of why the color of the blood is so red in the TS appears not definitive.

4.3) THE BLOOD STREAMS ON THE FACE

According to Lavoie et al.[24], some bloodstains are in a position which is not correct in comparison with the image, because **geometric distortions** are present.

For example the blood marks seen on the face and hair of the TS image were originally on the face (forehead, temples, cheeks and beard) but not on the hair of the Man covered by the TS. This was confirmed by experimental test. It was showed that a blood mark on the cheek impressed on a sheet that wraps the face (cylindrical distortion) appears to be in the hair position if a vertical projection of the face image (orto-photograph) is considered.

This evidence shows that the blood marks impression on the TS and body image formation are mechanisms related to different body-sheet configurations. This fact is coherent with the conclusion that the bloodstains formed before the body image because no image-fibers have been found under the bloodstains.

Accounting to the cylindrical distortion, as a result the bloodstains were placed in the correct position on the face in Figure 7.

Figure 7: 3D face of the TS Man[25]: some blood drippings visible on the hair were corrected to correspond to the cheek position.

5) SUMMARY OF BLOODSTAINS CHARACTERISTICS

About the **bloodstains**, the **characteristics** that must be considered by any researcher that wants to reproduce the TS in a laboratory are the following:

a) it is **human blood of** AB group;
b) the type 1 blood has **coagulated on the skin** of a wounded person; it has been transposed on the cloth because of the **fibrinolysis** of the blood clots present on the human body that was wrapped in the sheet and not by a simple "painting" with fresh blood; blood clots have a pale internal zone and **sharp and evident edges**; they are depressed in the centers, raised on the edges and have a pale halo of **serum**;
c) the type 2 blood has gone out from the side wound **after the death**; it is separated in a dense part and a serous part;
d) the sudden traumas are confirmed by the extraordinarily high level of **bilirubin** found in the blood;
e) the type 1 blood clots of **nailing** show that the Man enveloped by the TS was crucified in **vertical position**;
f) the fibrinolysis **stopped after few hours** (not more 36-40) because of the end of the contact between the body and the sheet;
g) the transposition of the **blood** on the cloth **forestalls** the formation of the **image**;
h) some bloodstains are in a position which is not correct in comparison with the image, then **geometric distortions** are present.

6) BLOOD CHARACTERISTICS THAT ANY SHROUD COPY MUST HAVE

Frequently who tries to copy the TS makes experiments trying to reproduce only the face. Who makes it rarely studies the blood problems, but if anybody affirms that the result of an experiment is similar to the TS, he must consider how much his result is far from the peculiar characteristics of the bloodstains detected by rigorous studies.

Until today somebody[13] keeps on affirming that it is possible to duplicate the TS, but until now no experimental test are capable to reproduce contemporarily all the peculiar characteristics detected.

The following comments are written to show how distant are the laboratory results from the TS, only considering the bloodstains point of view.

Technological impossibility to build a body image like that of the TS is discussed in another paper[6].

The following hypotheses, proposed by those researchers who think to be able to construct a TS copy, are subdivided in two categories:

a) results based on the enveloping the corpse of a man wounded to death;
b) results from an artist intervention.

6.1) RESULTS BASED ON THE ENVELOPING THE CORPSE OF A MAN WOUNDED TO DEATH.

As discussed, each proposed hypothesis, such as contact corpse-sheet or energy radiation, is acceptable from a blood stain point of view. All the hypotheses that consider the human body enveloping[6], such as the diffusion, direct contact or mixed mechanism, are coherent with the blood traces found on the TS. Also the hypothesis of a radiation mechanisms is acceptable even if only a "burst of energy" can be hypothesized because no alteration of the bloodstains have been detected (excluded the blood burnt by the Chambéry fire).

6.2) RESULTS FROM AN ARTIST INTERVENTION.

Many hypotheses have been done by different researchers such as that of painting, modified carbon dust technique, singeing or rubbing a sheet on a bas-relief, but all of them does not consider the presence of a corpse.

If so, according to Item (a) of §5, anyone who wants to make a copy of the TS has to choose not a painting pigment but human blood of AB group.

According to Item (b and c) of §5, anyone who wants to make a copy of the TS has to choose two different types of blood: that coagulated on the skin and transposed by fibrinolysis from blood clots, and that separated, come out after the death. To obtain the separated blood anyone has to catch the blood of a man and to prepare accurately it in a laboratory.

According to Item (d) of §5, the chosen blood had to be very particular: it had to be caught from a person having an extraordinarily high level of bilirubin in the blood, likely a person tortured to death;

According to Item (e) of §5, the artist had to "paint" the blood clots according to the gravity law applied to a person in a position like that of the crucifixion. Furthermore the artist had to very accurately "paint" the signs of the wounds as reported in Figure 2.

According to Item (f) of §5, the artist had to put away the cloth in contact with the clots after 36-40 hours.

According to Item (g) of §5, he has consider that the bloodstains have to be placed before the body image and any body image process has not to interact with the bloodstains.

According to Item (h) of §5, he has to "draw" some bloodstains in a position, which is not coherent with the "painting", but it is coherent with a cylindrical distortion that simulates the draping of the TS on the corpse.

7) CONCLUSIONS

This paper deeply considers the characteristic of the "red stains" detected on the Turin Shroud in order to show how difficult is to reproduce the Shroud in a laboratory only from a "red stains" point of view.

From a bibliographic analysis it is firstly shown that the "red stains" are bloodstains of two different types: 1) the blood that came out when the man was still alive, such as that of scourging and crown of thorns wounds or wrists wounds, that transposed on the cloth by a fibrinolysis process, and 2) the blood that came out after the death, such as that of feet wounds or side wound, with blood separation in a dense part and a serous part.

There also are highlighted many peculiar characteristics that must be taken into account for any Shroud copy.

At the end there are listed all the operations necessary for an hypothetical artist to obtain a result comparable with that of the Shroud. It is then highlighted how it is difficult, even more for an hypothetical medieval forger, to "build" a copy of the Shroud, only from a bloodstain point of view. The nonsense of reaching such a "wrong" (but coherent with cylindrical distortion, non-conforming with the traditional styles) and uselessly complicated result is not discussed because it seems to be obvious: the Shroud is not an artifact. In any case it must be considered that, as considered in another paper[6], even if the bloodstains problems are resolved, the body image formation problem remains a not resolved question for the present science.

8) REFERENCES

[1] Mechthild **Flury-Lemberg**: "Die leinwand des Turiner Grabtuches zum technischen befund", in: "The Turin Shroud. Past, present and future", Proceedings of the International Scientific Symposium of Turin, 2-5 March 2000, Effatà Ed., Cantalupa (TO) 2000, pp. 21-43.

[2] Eric J. **Jumper**, A. D. Adler, J. P. Jackson, S. F. Pellicori, J. H. Heller, J. R. Druzik: "A Comprehensive Examination of the Various Stains and Images on the Shroud of Turin", Archaeological Chemistry III, ACS Advances in Chemistry No. 205, Chapter 22, J. B. Lambert Editor, American Chemical Society, 1984, pp. 447-476; Larry A. **Schwalbe**, R.N Rogers: "Physics and Chemistry of the Shroud of Turin, A Summary of the 1978 Investigation", *Analytica Chimica Acta*, Vol. 135, 1982, pp. 3-49.

[3] John P. **Jackson,** E. J. Jumper, W. R. Ercoline: "Correlation of image intensity on the Turin Shroud with the 3D structure of a human body shape", *Applied Optics*, Vol. 23, No. 14, 15 July 1984, pp. 2244-2270.

[4] Roberto **Basso**, G. Bianchini, G. Fanti: "Compatibilità fra immagine corporea digitalizzata e un manichino antropomorfo computerizzato ", Worldwide Congress *Sindone 2000*, Orvieto, August 27-29, 2000.

[5] John P. **Jackson**: "Is the image on the Shroud due to a process heretofore unknown to modern science?", *Shroud Spectrum International* No. 34, March 1990, pp. 3-29.

[6] Kevin **Moran**, G. Fanti: "Does the Shroud body image show any physical evidence of Resurrection?", 4th International Scientific Symposium, Centre International d'Études sur le Linceul de Turin, Paris, April 25-26, 2002.

[7] Ray R. **Rogers**: Comments on "The Resurrection of the Shroud" by M. Antonacci, Internet: http://www.shroud.com/pdfs/rogers.pdf

[8] Giorgio **Frache**, E. Mari Rizzati, E. Mari: "Relazione conclusiva sulle indagini d'ordine ematologico praticate su materiale prelevato dalla Sindone", in: "La Santa Sindone – Ricerche e studi della Comm. di Esperti nominata dal Card. Michele Pellegrino, nel 1969", Suppl. Rivista Diocesana Torinese, Gennaio 1976, pp. 49-54.

[9] John H. **Heller**, A. D. Adler: "Blood on the Shroud of Turin", *Applied Optics*, Vol. 19, No. 16, August 15, 1980, pp. 2742-2744.

[10] John H. **Heller**: "Report on the Shroud of Turin", Houghton Mifflin C., Boston 1983, p. 144.

[11] John H. **Heller**, A. D. Adler: "A chemical investigation of the Shroud of Turin", *Canadian Society of Forensic Sciences Journal*, Vol. 14, No. 3, 1981, pp. 81-103.

[12] Walter C. **McCrone**, C. Skirius: "Light microscopical study of the Turin 'Shroud' I", *The Microscope* 28, No. 3, 1980, pp. 105-113; Walter C. **McCrone**: "Light microscopical study of the Turin 'Shroud' II", *The Microscope* 28, No. 4, 1980, pp. 115-120; Walter C. **McCrone**: "Light microscopical study of the Turin 'Shroud' III", *The Microscope* 29, No. 1, 1981, pp. 19-39.

[13] Walter C. **McCrone**: "Shroud image is the work of an artist", *The Skeptical Inquirer* 6, No. 3, 1982, pp. 35-36; Walter C. **McCrone**: "The Shroud of Turin: blood or artist's pigment?", *Accounts of Chemical Research*, American Chemical Society, 23, 1990, pp. 77-83; Walter C. **McCrone**: "Shroud 1999", *The Microscope* 47, No. 1, 1999, pp. 55-61; Walter C. **McCrone:** "The Shroud Image", *The Microscope* 48, No. 2, 2000, pp. 79-85.

[14] David **Ford**: "The Shroud of Turin's 'blood' images: blood, or paint? A history of science inquiry", 2000, http://www.shroud.com/pdfs/ford1.pdf

[15] Pier Luigi **Baima Bollone**: "Indagini identificative su fili della Sindone", *Giornale della Accademia di Medicina di Torino*, No. 1-12, 1982, pp. 228-239.

[16] Pier Luigi **Baima Bollone**, M. Jorio, A. L. Massaro: "La dimostrazione della presenza di tracce di sangue umano sulla Sindone", *Sindon*, Quaderno No. 30, Dicembre 1981, pp. 5-8.

[17] Pier Luigi **Baima Bollone**, M. Jorio, A. L. Massaro: "Identificazione del gruppo delle tracce di sangue umano sulla Sindone", *Sindon*, Quaderno No. 31, Dicembre 1982, pp. 5-9.

[18] Pierre **Barbet**: "La prova della autenticità della Sindone nelle sue macchie di sangue", *Sindon*, Quaderno No. 14-15, Dicembre 1970, pp. 21-43.

[19] Gilbert R. **Lavoie**, B. B. Lavoie, V. J. Donovan, J. S. Ballas: "Blood on the Shroud of Turin: Part II – The importance of time in the transfer of blood clots to cloth as distinctive clot images", *Shroud Spectrum International*, No. 8, September 1983, pp. 2-10.

[20] Carlo **Brillante**: "La fibrinolisi nella genesi delle impronte sindoniche", in: "La Sindone, Scienza e Fede", Atti del II Convegno Nazionale di Sindonologia, Bologna 27-29 Novembre 1981, CLUEB, Bologna 1983, pp. 239-241.

[21] Carlo **Goldoni**, T. Grimaldi Di Marco, M. Moroni: "Sindone: raffronto tra il singolare colore delle macchie di sangue e la concentrazione di bilirubina in esso. Prime investigazioni", *Sindon Nuova Serie*, Quaderno No. 14, Dicembre 2000, pp.98-102 and 131- 146.

[22] Alan D. **Adler**: "The origin and nature of blood on the Turin Shroud", in: "Turin Shroud – Image of Christ?" Proceedings of the Symposium of Hong Kong, 3-9 March 1986, Cosmos Printing Press Ltd., Hong Kong, March 1987, pp. 57-59.

[23] Pierluigi **Baima Bollone**, C. Marino, G. Pescarmona: "Il significato del colore delle macchie di sangue della Sindone ed il problema della bilirubina", *Sindon Nuova Serie*, Quaderno No. 15, Giugno 2001, pp. 19-29.

[24] Gilbert R. **Lavoie**, B. B. Lavoie, A. D. Adler: "Blood on the Shroud of Turin: Part III – The blood on the face", *Shroud Spectrum International*, No. 20, September 1986, pp. 3-6.

[25] Giulio **Fanti**, E. Marinelli: "Cento prove sulla Sindone: un giudizio probabilistico sull'autenticità", Ed. Messaggero, Padova 1999 and Internet: http://www.shroud.com/fanti3en.pdf