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The Sudarium of Oviedo and the Shroud of Turin. A question of authenticity

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Abstract

The authenticity of the Sudarium of Oviedo and the Shroud of Turin is a complex issue that should be supported by a combination of medical and scientific analysis, and the evidence from anthropology, archeology and history. This paper describes how past research, and particularly the research related to the Sudarium of Oviedo, may contribute to give some answers related to the authenticity problem, but the results are still inconclusive. The use of new digital image processing techniques, quantitative color analysis and stains images matching methods can contribute to compare both cloths and solve some pending issues related to their authenticity.

Keywords: History, Forensic studies, Digital image processing and Image matching techniques.

1. INTRODUCTION

The Shroud of Turin is among the most known, controversial and enigmatic of the archeological artifacts. It shows the image of a tortured man. Various marks resembling wounds are visible on the body image. Areas having the characteristics of scorch marks and water marks are also identified.

Scientific research of the Shroud of Turin began in 1900 at the Sorbonne University under the direction of Yves Delage, professor of comparative anatomy. Additional tests have been performed on the Shroud by diverse scientific teams from Italy, USA and other countries. During the 1978 test program, members of Shroud of Turin Research Project (STURP) performed photographic imaging; visible, ultraviolet, and infrared (IR) spectroscopy; IR termography; x-ray fluorescence analysis; and x-radiographic imaging. They also collected microscopic samples for chemical testing. Details of these tests with results can be found in [9].

The Sudarium of Oviedo, kept in the Cathedral of Oviedo, north of Spain, is less known. The Sudarium is a small bloodstained piece of linen (84 x 53 cm), but no image appears on it. Scientific research of the Sudarium began in the mid 1960´s by Monsignor Giulio Ricci.

The Investigation Team from the Spanish Centre for Sindonology studied the Sudarium in Oviedo for the first time in November 1989 and several times in the nineties. Apart from studying the cloth as it appears to the naked eye, photographs were taken from various angles and distances, and with normal light as well as ultraviolet and infrared light. Samples of dust and pollen were taken, as well as small samples of the cloth itself.

Results of these studies and tests can be found in [7, 11]. The Sudarium of Oviedo is also as controversial and enigmatic as the Shroud of Turin because many people believe both cloths are relics related to Jesus of Nazareth passion and death.

The approach for the question of authenticity is a complex issue that should be supported by a combination of medical and scientific analysis, and the evidence from anthropology, archeology and history. This approach may be divided into three stages:

1. Establish that each cloth is a genuine cloth removed from a corpse.
2. Determine both cloths as belonging to a particular corpse.
3. Establish an association of both cloths with the historical person of Jesus of Nazareth.

The scope of this paper is to describe how past research of both cloths, and particularly the research related to the Sudarium of Oviedo, may contribute to give answers related to the problems issued in stage 1, and partially in stage 2 of the approach proposed above, but are inconclusive for establishing the association of both cloths with the historical person of Jesus, that is stage 3.

The comparative study of both cloths is a precondition for obtaining conclusive results. Particularly, the use of new digital image processing techniques, quantitative color analysis and stains images matching methods can contribute to establish the two cloths contacted the same body.

2. THE SUDARIUM OF OVIEDO

The Sudarium of Oviedo is kept at the Cathedral of Oviedo, north of Spain. The Sudarium is a small bloodstained piece of linen (84 x 53 cm), but no image appears on it.

Figure 1. The Sudarium of Oviedo.

The Sudarium's existence and presence in Oviedo is well attested since the eighth century and in Spain since the seventh century. Before these dates the location of the cloth is less certain.

The history of how this cloth reached Oviedo is well described by Mark Guscin [6]. He describes that most of the information comes from the twelfth century bishop of Oviedo, Pelagius (or Pelayo), whose historical works are the Book of the Testaments of Oviedo, and the Chronicon Regum Legionensium. According to this history, the Sudarium was in Palestine until shortly before the year 614, when Jerusalem was attacked and conquered by Chosroes II. It was taken away to avoid destruction in the invasion, first to Alexandria by the presbyter Philip, then across the north of Africa when Chosroes conquered Alexandria in 616. The Sudarium entered Spain through Cartagena, along with people who were fleeing from the Persians. The bishop of Ecija, Fulgentius, welcomed the refugees and the relics, and surrendered the chest, or ark, to Leandro, bishop of Seville. He took it to Seville, where it was for some years.The Sudarium was then taken further North to avoid destruction at the hands of the forces of Muslim Arabs and Berbers, who conquered the majority of the Iberian peninsula at the beginning of the eighth century. This possible itinerary is shown in Figure 2.

The Sudarium was first kept in a cave that is now called Monsacro, near Oviedo. King Alfonso II had a special chapel, called the "Cámara Santa" (Holy Chamber), that later was incorporated into the Oviedo cathedral.

The key date in the history of the Sudarium is the 14th March 1075, when the chest containing it was officially opened in the presence of King Alfonso VI. A list was made of the relics that were in the chest, and which included the Sudarium. In the year 1113, the chest was covered with silver plating, on which there is an inscription inviting all Christians to venerate this relic which contains the holy blood.

Figure 2. A proposed Sudarium itinerary.

The sudarium has been kept in the "Cámara Santa" where other important objects are hold. Amongst these are two crosses of immeasurable value. The first is the cross of Angels; a gift from King Alfonso II and the emblem of the city and the second is the cross of Victory, the symbol of the region with a deep story to its origin.

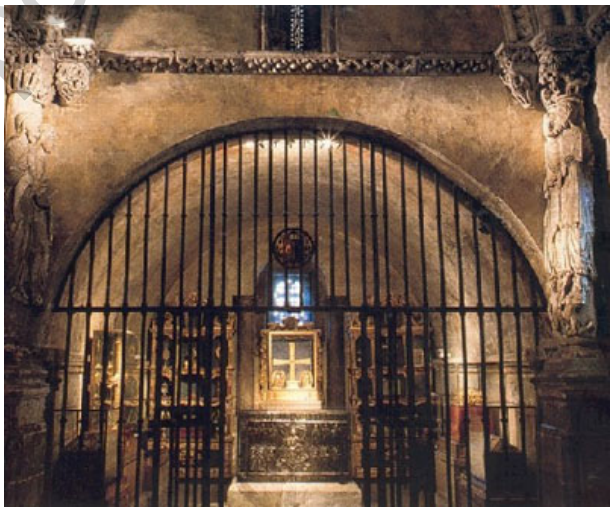

Figure 3. The "Cámara Santa".

The Sudarium is mounted in a wooden frame sheathed in silver. The Sudarium is displayed to the public three times a year: Good Friday, the Feast of the Triumph of the Cross on 14 September, and Saint Matthew festivity, on the 21 of September.

3. SCIENTIFIC STUDIES ON THE SUDARIUM

Monsignor Giulio Ricci is considered to be the main contributor to the earlier studies of the Sudarium. In 1965 he compared for the first time the blood stains of the Sudarium and the Shroud of Turin. He published his

results in the book: "L´Uomo della Sindone è Gesù", in 1969.

Max Frei took pollen samples of the cloth in 1979. He noted some coincidences and differences in the pollens found in the Sudarium and the Shroud of Turin [11].

Balma Bollone did the first blood studies of the Sudarium. Similar studies were later performed by Carlo Goldoni [11].

The author examined the Sudarium in 1984. He had a meeting in Danbury (CT), with Alan Adler in May 1986 for the identification of the most feasible sampling and testing techniques. After he sent some Sudarium photos to them. Unfortunately, we did not have the necessary financial support to continue the studies.

The Investigation Team from the Spanish Centre for Sindonology, named EDICES in Spanish, studied the Sudarium in Oviedo for the first time in November 1989 and several times later. Apart from studying the cloth as it appears to the naked eye, photographs were taken from various angles and distances, and with normal light as well as ultraviolet and infrared. Samples of dust, pollen and blood were taken, as well of minute samples of the cloth itself. The details of these studies are published in [7, 11]. For the sake of brevity, here we summarize some of the EDICES findings:

- They named the two sides of the cloth as Observe and Reverse, and the groups of stains as Observe Left and Right and Reverse Left and Right.
- The Oviedo Sudarium cloth is made of poor quality linen compare to the Shroud. The weave pattern called taffeta is perpendicular in wrap and weft (See Figure 4).

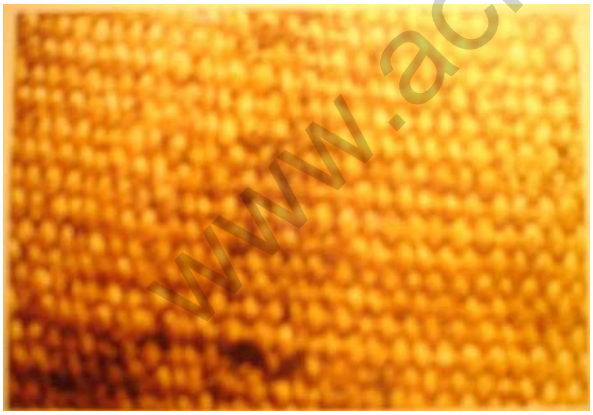

Figure 4. Weave pattern of the Sudarium.

- 30 types of pollen were found. Carmen Gomez from Complutense University in Madrid continued Max Frei´s work. She confirmed that there is pollen from Palestine present on the cloth (Quercus, Pistacia Palestina and Tamarix) [11]. But Maria Jose Iriarte own conclusions, presented at the 2st International Congress on the Sudarium of Oviedo, were quite different, stating that she was not able to identify pollen that could pin the Sudarium down to any given geographical location.
- The Sudarium is dirty and burnt in parts, stained and highly contaminated. According to EDICES microscopic observation there is no doubt which area of the cloth was in direct contact with the face of the corpse. This area is called by them the "Reverse Left" side. There is much more haematic substance in this cloth side than any other.
- The main Sudarium stains consist of one part of blood and six parts of pulmonary edema fluid. The central group of stains are superimposed on each other (See Figure 1).
- Professor of Forensic Medicine at the University of Valencia, José D. Villalain and EDICES member, was able to simulate the fluid coming out the corpse and to estimate the time elapsed between the formation of each superimposed stain by reproducing the mixture of blood and the fluid from the edema, and having a specially modeled head to recreate the flow of this fluid (See Figure 5).

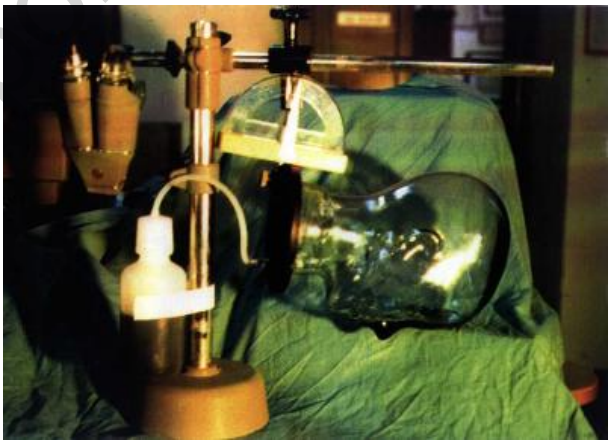

Figure 5. Specially modeled head for fluid flow simulation.

- The Sudarium wrapped the head of a dead and tortured man. The cloth was placed over the head starting from the back, held to the hair by sharp objects.
- Once the man had died, he stayed in a vertical position for around one hour. His body was then placed on the ground on its right side. The forehead was placed on a hard surface and the body left in this position from approximately one more hour.
- His body was then moved, while some of the persons transporting the corpse, left his hand in various positions trying to stem the flood of liquid from the corpse's nose and mouth. The corpse movement could have taken about 5 minutes.

- Finally, on reaching the destination, for unknown reasons, the cloth was taken off the head.
- The man's death is compatible with crucifixion and the wounds inflicted before death as they are observed on the Shroud of Turin.

4. COMPARISON STUDIES

Since blood stains are the main feature of the Sudarium (See Figure 1), the comparison studies to relate it to the Shroud are mainly focused in the blood stains comparison based on the identification of forensic, chemical and geometrical correspondences.

The blood is human and of the AB group on both cloths.

The size of the stains is geometrically compatible considering their relative position in each cloth (see Figure 6).

Figure 6. Blood stains correspondence (from Centro Español de Sindonología).

Considering forensic studies of how stains are produced in both cloths, it is necessary to mention that stains do not necessarily have to match on a flat surface.

The stains formed by blood shed in life seem the same on each cloth. The stains occupy the positions predictable from the image formation of the Shroud.

There are coincidences between anatomical elements of the Sudarium and the man of the Shroud as presented in Table 1.

TABLE 1. Anatomical correspondences

Element	Sudarium	Shroud
Total area of the	2280,00 mm^2	2000,00 mm^2
Swelling on the right side of the nose	100 mm^2	90,00 mm^2

Possibly myrrh and aloes were sprinkled over both cloths [11].

It seems a sample from the Sudarium was carbon-dated around 700 AD [6]. As it is well known, the Shroud samples were carbon-dated 1260-1390 AD. These are controversial results that need additional research.

Attempts to identify nuclear DNA on the Sudarium were unsuccessful. However the Antonio Alonso team from the National Institute of Toxicology and Forensic Sciences, located in Madrid (Spain), was able to identify a human mitochondrial DNA.

A Whanger and M. Whanger applied the polarized image overlay technique as a comparison method for stains in the Shroud and the Sudarium. They applied this technique some years ago to compare the Shroud with old icons of Jesus [14].

They applied this technique to the Sudarium, comparing it to the blood stains on the Shroud of Turin. It seems they found seventy points of coincidence for frontal stains and fifty for the rear side [6]. The validation of these results is needed to consider them firm. The image matching methods proposed below may contribute to the validation of these results.

Nello Balossino photographically scanned the Sudarium in November 2006. He presented some results at The Second International Conference on the Sudarium of Oviedo [3]. They scanned images directly from the Sudarium in A3 format with different resolution: 300, 600 and 1200 dpi, and 16 bit color depth for either channel Red, Green and Blue. They obtained the components HSL (Hue, Saturation and Luminance) from the Sudarium. They showed an example of 2D superimposition (with different kind of pseudocolor) giving evidence that there is some mapping area belonging to the Sudarium and the Shroud.

The testing and analysis of the last few years, summarized here for the Sudarium and elsewhere for the Shroud [9], goes further in demonstrating that both cloths are genuine burial cloths from antiquity rather than the result of a medieval forger. But further studies should be conducted by coordinated and multidisciplinary international teams. Those studies would be directed towards comparing quantitatively blood stains features, forensic studies, chemical properties, pollen, historical documents and other research issues of interest.

5. A PROPOSAL OF NEW COMPARISON STUDIES

The comparative study of both cloths is a precondition for establishing an association of both cloths with the same person. Particularly, the use of some non-intrusive digital image processing techniques, quantitative color analysis and stains images matching methods can contribute to the realization of the authenticity approach described in the introduction.

Digital image processing, that is the manipulation of images by computer, has been applied in practically every type of imagery [4]. Digital image processing basically

requires a computer upon which to process images. In addition, as seen in Figure 7, the system must have two pieces of special input/output equipment, an image digitizer, currently a scanner, and an image display device.

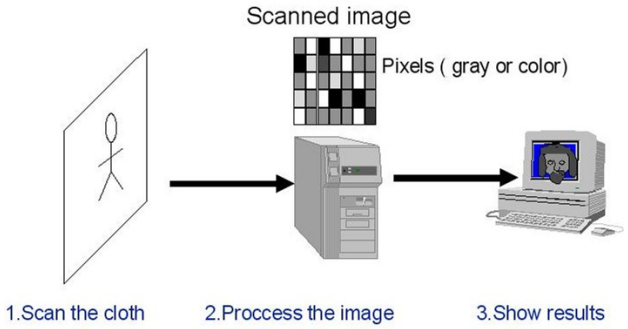

Figure 7. A digital image processing system.

Here in figure 7, we realize that a cloth can be scanned directly since it has been done nowadays for the Shroud and the Sudarium as mentioned above. This approach avoids the use of photographs with the particularities of the photographic film that are particularly evident in the tonal distortion of the image of the Enrie photographs taken in 1931. In the late seventies, Shroud photographs were scanned using a microdensitometer [8], a precision instrument able to read minute changes in image intensity, doing this by measuring the amount of light able to be transmitted through the image from point to point. The density value of each checkerboard square is known as a pixel (picture element). Currently, we use scanners that may be hand-held, flatbed or drum. Scanners are devices that optically scan images or text and convert it to a digital image, see step 1 of Figure 7. Modern scanners typically use a charge-coupled device (CCD) or a Contact Image Sensor (CIS) as the image sensor.

Processing an image, as seen in Figure 7, starts with one image, here the scanned image, and produces a modified version of that image, that may be presented in a display. The term digital image analysis is taken to mean a process that transforms a digital image into something other than an image, such as a set of measurement data or a decision [4]. The term digital image processing is loosely used to cover both processing and analysis.

Since the earlier work by Avis et al [1] and Tamburelli [13], diverse digital image processing techniques have been used and proposed for the Shroud. Some are mentioned here: simple contrast enhancements, spatial and spectral filters, geometric transformations, color enhancements, false color representation, simulations, image classification, quantitative comparison of images and quantitative color analysis.

A very promising and recent work regarding quantitative analysis of the Shroud image has been presented at the Ohio Conference by R.J. Schneider [12]. He used images taken by Barry Schwortz in 1978 and Durante in 2000, and known software tools such as Adobe Photoshop Elements, Python PIL, Matlab Image Processing Toolbox, CVI Ptools and Image J. He compared the same regions of different Shroud images. The problem to be solved was related to what is called image segmentation, involving the partitioning of image into regions and distinguishing from one another different elements in the Shroud that area cloth banding, image, blood, scorch and others. He converted a full range Shroud image to an indexed image with far fewer colors and applied contrast stretching of the separated color unit vectors. This processing seems to give a good segmentation of the main categories of interest. Considering the results, he proposes to explore the application of statistics taken from different image categories and seek to create a pixel classification algorithm that would automatically assign pixels to categories (blood, cloth, image) by their relation to the criteria [12].

Considering the similarities in the blood stains present in the Sudarium and in the Shroud but taking into account that the same face can produce different stains, especially in different cloths, and different faces can produce similar stains, the comparison of blood stains in both cloths is still an open issue.

Quantitative approaches for image segmentation such as the Schneider approach mentioned above, can give more objective results for blood stains comparison of the Shroud and the Sudarium than some subjective comparisons applied in earlier studies. Subjective comparisons may be biased by our visual perception system and brain interpretation. Some images of Mars, as the one presented in Figure 8 are illustrative of how subjective interpretation of images can produce misleading results.

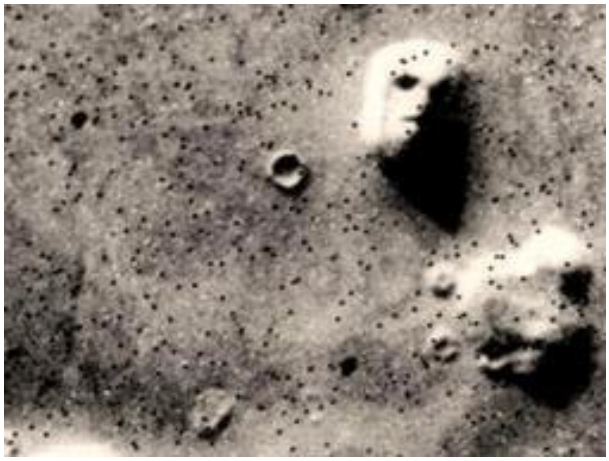

Figure 8. A face on Mars surface?

Images matching methods can be classified as area based, feature based or symbolic. Area based methods use numerical comparison of digital numbers in subarrays from each of the images to perform the matching.

Feature-based methods involve the features extraction with subsequent comparison based on feature

characteristic. Symbolic methods are hybrid solutions that involve some combination of area based and feature based approaches [2].

Feature-based methods of images comparison consist of the following three steps: feature extraction, feature matching and transform model estimation [15]. Identifying image features that are invariant to image scaling, rotation and partially invariant to changes in illumination is an important issue for the comparison of the Shroud and Sudarium blood stains. It would seem that a set of parameters that gave nearly the same scaling, orientation and translation for multiple features, which be a very confirming issue that the two cloths had derived their markings by, contact with the same body and configuration of blood stains. Also it is important to realize that cloths have different weave patterns, the Shroud has a herringbone pattern and the Sudarium as mentioned above has a taffeta pattern.

Conventional image features are broadly classified into three types: salient points, lines and regions in the image. Corners may be used as features in some images. Line features can be the representation of general line segments in given images and object contours. Region features can be used to detect the projection of high contrast closed-boundary regions and patterns [15].

The approaches described above, lead the author to propose the quantitative comparison of Sudarium and Shroud blood stains using digital image processing techniques and following these steps:

1. Propose the candidate features to extract from the blood stains images.
2. Extract the features from Sudarium, Shroud and blood stained control cloths.
3. Feature matching.
4. Make a firm connection between the two cloths to show that they covered the same body.

Another interesting technology that combines digital imaging techniques with common spectroscopic methods is called hyperspectral imaging technology, currently limited to 100x 100 mm2 maximum field of view [5].

Hyperspectral image technology was used to analyze some of the stained bills, which had been recovered from the suspects, as well as bills collected from the victims' home with similar stains. Hyperspectral images and associated spectra determined that the stains on the currency from the victims' home appeared to have the same optical properties under these specific lighting conditions in comparison to the stains on the currency seized from the suspects. Based on this information, the expert witness testified that there was no discernable difference in appearance and behavior between any of the stained bills obtained as evidence, which was consistent with the possibility that the bills originated from a common source. This information was included in the report that was admitted as evidence submitted and accepted in the trial [5].

6. CONCLUSIONS

As mentioned by the archeologist professor W. Meacham's: *Current opinion in Shroud authenticity ranges generally from "probable" to "proven" for stage 1 and from "possible" to "probable" for stage 2* (stage 3 in the approach presented here). *For a variety of reasons, not the least of which the fact the object is a religious relic, these opinions seem to err on the side of the cautious place, undue emphasis on negative evidence and are based on an assumption that the identity of the Shroud man is "unprovable"* [10].

Quantitative comparative analysis of blood stains for both cloths can be a contributing input for the answer to stages 2 and 3 of the authenticity question. Scanned files of both cloths are already available. It is out of the scope of this paper to describe the protocol to be used for the quantitative comparative analysis of the blood stains but to give some recommendations from the point of view of digital image processing techniques.

Most computer science methods of determining a matching between two images consist of feature extraction and feature matching. It is important to identify qualitative and quantitative features valid for the blood stains on both cloths. Features invariant to rotation, translation or scaling should be an important comparison issue.

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