THE FIELD AND LABORATORY REPORT
OF THE
ENVIRONMENTAL STUDY OF THE SHROUD
IN
JERUSALEM

by

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PREFACE

The success of any project depends on those who participate in it and I have been fortunate to have worked with some truly exceptional people. Joseph Kohlbeck, Resident Scientist at Hercules Aerospace, became the originator of the project which is now known as the Environmental Study of the Shroud in Jerusalem. Dr. Ray Rogers, when loaning the Mylar tapes to Kohlbeck, called him, "One of the best with a microscope." That praise is borne out by the quality photomicrographs taken by Kohlbeck which have been used in this report. However, expertise of Kohlbeck's caliber is much in demand and unfortunately, he has been pulled away from this project leaving me to make the interpretation, some analysis, and the synthesis of the materials. It is for this reason that I must caution those who use this report that the opinions expressed here are mine and not necessarily those of Kohlbeck or any other staff member.

The weight of the work has been placed on the archaeological context of the Shroud and for this I offer no apology, since it has been an aspect seriously neglected in the past. The environment of the tomb is more complex than we expected. There is a tremendous need to do further research in this area. To study the Shroud in Turin alone is to see only part of the picture.

Those team members who participated in the Jerusalem testing include:

Sister Damian, OCD (Coordinator & Archaeological Advisor).
Sister Mary Joseph, OCD (Nurse & Medical Advisor).
Carl F. Nitowski (Video tape).
Harold B. Nelson (Secretary/Recorder; Director, Corpus Christi Holy Shroud Memorial, Corpus Christi, Texas).
Lynn Johnson (Photographer; Salt Lake City Tribune).
Dr. James Strange (Archaeologist; Dean of the University of South Florida).
Dr. Donald Wimmer (Archaeologist; Professor of Religion, Seton Hall University).

My very special thanks go to the Official Observers who are members of other groups who independently paid their own way to insure an unbiased and scientifically correct approach to the testing and maintenance of standards. Those participants include:

Rodger Apple (Executive Director, Albany Center Turin Shroud, Albany, New York).
Constance Apple (Albany Center Turin Shroud, Albany, New York).
Rex Morgan (Editor Shroud News, Australia; member Board of Directors ASSIST).

Other ESSJ team members not participating in the Jerusalem testing

Joseph Kohlbeck (Resident Scientist, Hercules Aerospace).
Deborah O'Connor, RN (Nurse & Medical Advisor; University of Utah Medical Center).
Elizabeth McConnell (Medical Research; University of Utah).
Kyle Fernandez, RN (Medical Research; University of Utah Medical Center).
Donald Riding (Scientific photography; Hercules Aerospace).
Christa Powell (Filming).
Hugh Claycombe (Graphics).

ABBREVIATIONS USED FOR PERIODICALS:

AJA = American Journal of Archaeology.

AUSS = Andrews University Seminary Studies.

BA = Biblical Archaeologist.

BAR = Biblical Archaeology Review.

BASOR = Bulletin of the American Schools of Oriental Research.

IEJ = Israel Exploration Journal.

PEQ = Palestine Exploration Quarterly.

RB = Revue Biblique.

INTRODUCTION

The Environmental Study of the Shroud in Jerusalem (ESSJ), which began in 1983, has taken an entirely new approach to Shroud studies (sindonology). It does not begin its work in Turin, but rather, in Jerusalem where the Shroud would have originated if it is the burial cloth of Christ. The research team is composed of scientists, archaeologists, supporting specialists, and official observers whose aim has been to study the earliest environment of the Shroud - an ancient tomb - with emphasis on image formation.

There has been a severe and harmful lack of proper representation among biblical or Near Eastern archaeologists in sindonology. Reputable archaeologists have automatically and consistently reacted to the Shroud of Turin with the phrase, "ark hunt," that derogatory catch-all which places a topic in the catagory of religious fanaticism unworthy of scholarly research.

The Shroud will never be considered an area of legitimate study until its background is demonstrated correctly and with proper terminology. One must first realize that a biblical archaeologist is not necessarily concerned with proving the veracity of the Bible, but rather one who studies the remains and artifacts within the period and geographical area encompassed by the biblical record. With this in mind, it would be well to begin with a definition of the Shroud of Turin in archaeological terms.

Is the Shroud an archaeological artifact? If the immediate response is affirmative, the first difficulty is encountered, since the meaning of artifact by field standards is an object which is man-made or altered in some fashion. Therefore, to say that the Shroud is an artifact would imply a totally manufactured nature including image. If, however, the image is not deemed as man-made, one must restrict the term artifact to the cloth alone. If one opts for the broadest meaning of the word, that is, any object of antiquity, caution should be used as to the background of those with whom that definition is used.

Joined with that is thinking, far too limited, as to what actually comprises areas of archaeological investigation for sindon-

ology. Method is most evident and deficient when parallels are drawn between types found in Classical areas as opposed to those in Palestine. All previous archaeological investigation is clearly not enough. Context, as found in field research rather than museum or laboratory studies, is absolutely essential. The purpose of this report is to list all of ESSJ's test results to date and establish parameters for relevant subjects in an archaeological context for sindonology by examining the broadest range of topics to this point.

APPROACH TO THE PROJECT Because of the nature of the project, that of an environmental study of an ancient tomb, the group was especially conscious of prohibiting any substance or action which could possibly alter the environment in any way, no matter how slight. Such disturbance would nullify tests and results. For example, only battery powered lanterns were used rather than kerosine or candle types. The water for filling the manikin was heated outside the tomb and the manikin, while being filled with the heated water in the tomb complex was well away from the test chamber so that in both instances neither the temperature nor humidity of the test chamber were changed.

The site chosen, a tomb complex at the École Biblique et Archéologique Française, already contains an alteration to the structure which accommodates a modern mausoleum (Figure 1). This, in effect, has already made a disturbance to the structure, but, since it is only an architectural change, did not affect the testing.

The basis of all ESSJ's comparative testing has been the use of many of the Mylar tapes taken from the Shroud in 1978 by Dr. Ray Rogers of the Los Alamos National Laboratory. Study of the tapes enabled us to form theories which we tested in the field. It has been those same tapes which we have used comparatively for the analysis of the Jerusalem experimental materials.

TEST SITE Permission by both the authorities at the École Biblique and the Department of Antiquities of Israel to use a tomb complex on the property of the École for the project test site (Figure 1) was granted. This choice was due to the following considerations:

1. Although the tomb known as that of Joseph of Arimathea, which is situated behind the Edicule in the Church of the Holy Sepulchre (Figures 2 & 3), would be ideal as regards the proximity to the tomb most widely held to be the tomb of Christ,

disadvantages exist:
a. The tomb is too small to accommodate all the proposed tests;
b. There would be great difficulty in approaching the numerous and varied church authorities for permission for such extensive testing;
c. The site is too accessible to the public, which would cause serious disturbance at the time experimentation would be conducted;
d. The tomb is badly contaminated by candle burning, visitors, etc.

2. The site of the Garden (Gordon's) Tomb (Figure 4) meets with objections 1.a and 1.c above. In addition, this tomb is too open to the outside air from previous structural damage. The opening would be difficult, if not impossible to seal off.
3. The tomb complex at the École Biblique on the contrary:
   a. Provides ample area in a multi-chambered tomb. Each chamber can be sealed to allow at least five different experiments to be conducted simultaneously;
   b. Provides a typical sealed environment which has been little affected by exterior weather conditions;
   c. Provides access to the same rock shelf as both the Holy Sepulchre and the Garden Tomb, thereby including the two most notable choices for the tomb of Christ (Figure 5);
   d. Provides security from tourist visits, thereby insuring non-interference from outside sources; and
   e. Provides access to resources and equipment at the École.

DATE OF ON-SITE TESTING Because of the need to simulate, as closely as possible, 1st century conditions involved during the time of the crucifixion and interment of Christ, the date of the on-site testing was chosen to approximate the Passover/Easter season, and yet avoid both Latin and Greek Easter dates to keep tourist interference at a minimum. We hoped that this period would create the same climatic conditions of moisture and temperature. It was thought that, if the tomb environment did contain a mechanism for image production, quite possibly temperature and humidity would be important catalysts.

Because of these considerations and the research which is expected to be conducted in Turin in the near future, April of 1986 was chosen for the on-site testing. This would allow materials and preliminary test results to be analyzed for the use of those who will conduct hands-on research on the Shroud in Turin.

IMAGE TEST LIMITATIONS Image tests by previous researchers have often included the use of a cadaver in an attempt to be as accurate as possible in reduplicating the conditions of the crucifixion and death of the one whose image is borne on the Shroud of Turin. ESSJ

on the other hand, decided against the use of a cadaver for the following reasons:

1. The instability of a dead body with regard to temperature, duration of rigor mortis, and the beginning of decomposition;
2. The inability to meet the same physical conditions, such as blood and perspiration acidity, which if not met, must be artificially added to the body in the same fashion as a manikin
3. A cadaver cannot be heated to simulate a crucified body's temperature at death as well as post mortem fever. There is simply no way technically to make a cadaver radiate body heat from the center outward as opposed to any conventional heating method which would be from the exterior inward;
4. The addition of temperatures as high as those required would cause the beginning of rapid decomposition. When rigor mortis ceases, decomposition begins by a shift in the body's chemistry from an acid to an alkaline. This change to alkalinity would not meet the condition of the skin's surface in violent death which is acidic.
5. The religious beliefs, laws, and customs of the State of Israel would make the use of a cadaver highly inadvisable as well as illegal.

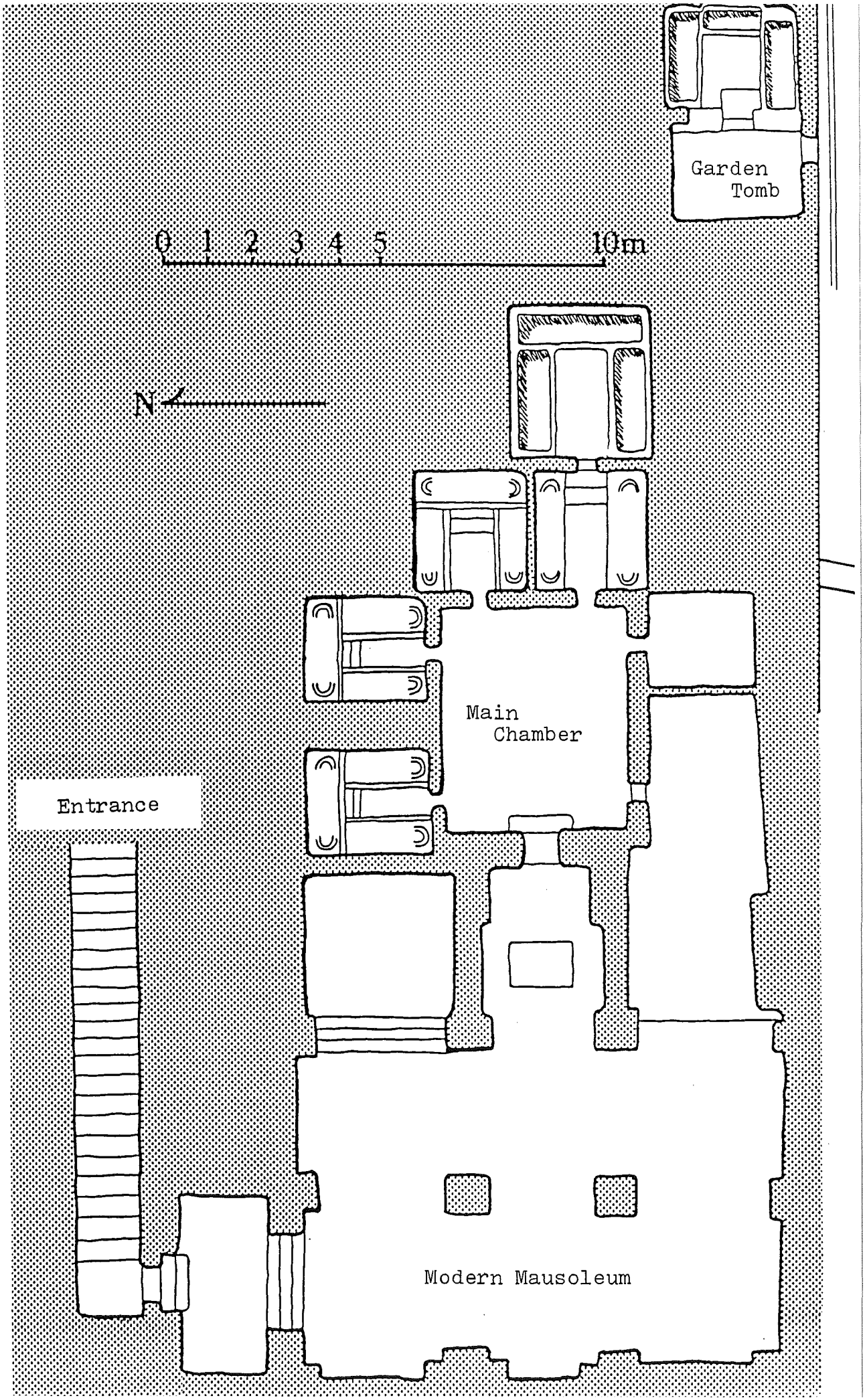
While the use of a specially built medical manikin seemed to answer all of the above objections, difficulties still remained:

1. A hollow manikin capable of being filled with heated water to simulate the body's temperature works to a limited extent. The water-filled manikin was the closest facsimile to the body which followed, somewhat, the same cooling pattern. However, a large volume of heated water in a manikin cannot retain heat in the manner of the more solid bone and muscle in a human body;
2. The manikin could not be positioned in the same manner as a body which had begun rigor mortis on the cross (see Figure 31).
3. It was impossible to eliminate air pockets when filling the manikin, causing an uneven heat contact with the test cloth.

The tests were performed in an attempt to include all possible conditions expressed in various theories for the natural production of an image, such as Vignon's vaporgraphic theory and Pellicori's latent image theory. Because of the nature of the samples taken and the analysis for the presence of contaminants, all of the samples were sealed on the site where they were taken to avoid contamination from outside sources.

The importance of this testing cannot be underestimated. The main objective has been the investigation and testing of a hypoth-

esis of the mechanism of image formation and, this being successful, it is compelling evidence that the Shroud of Turin is indeed a genuine burial cloth originating inside a Jerusalem limestone tomb.



igure 1.
omb complex
t the École
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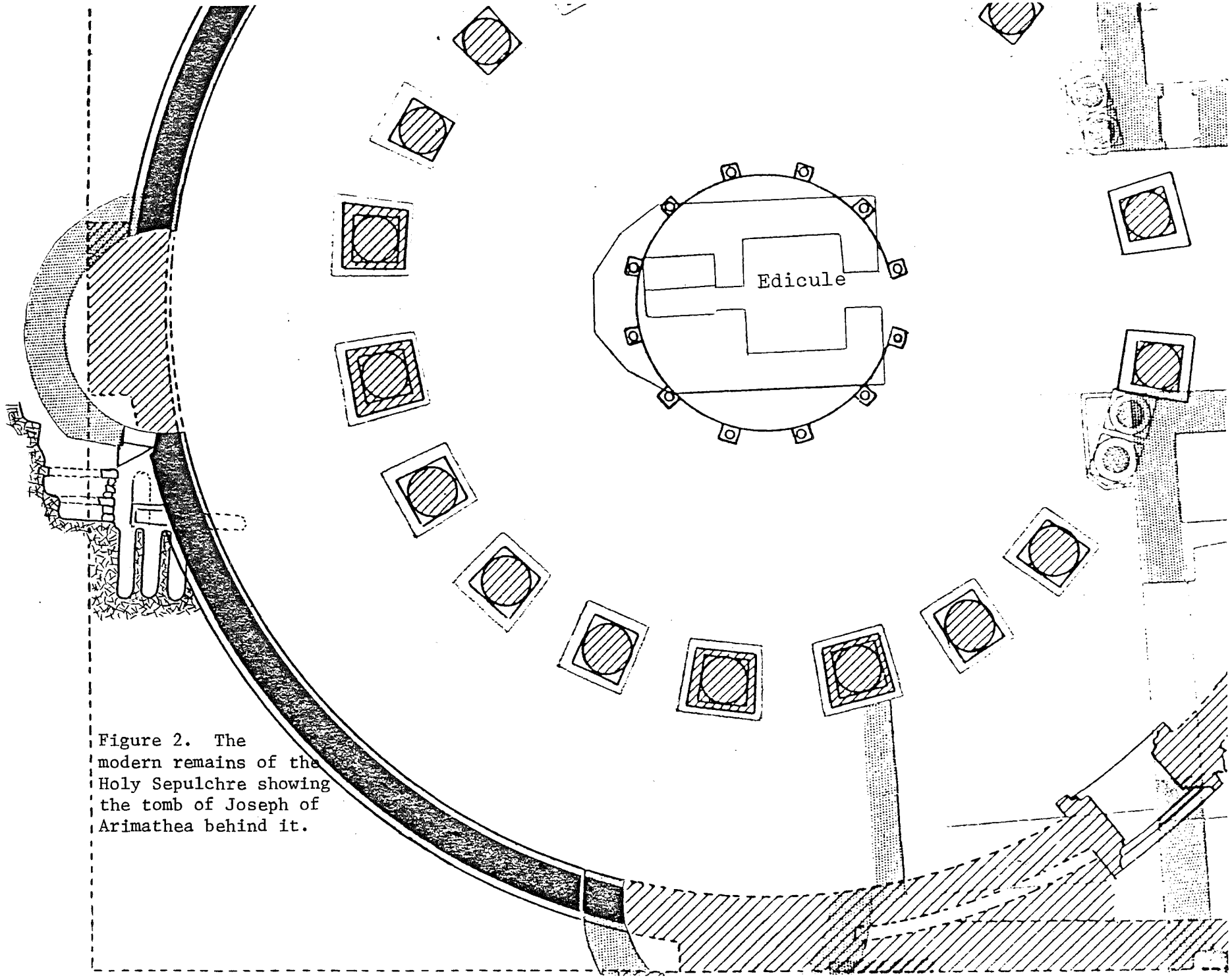
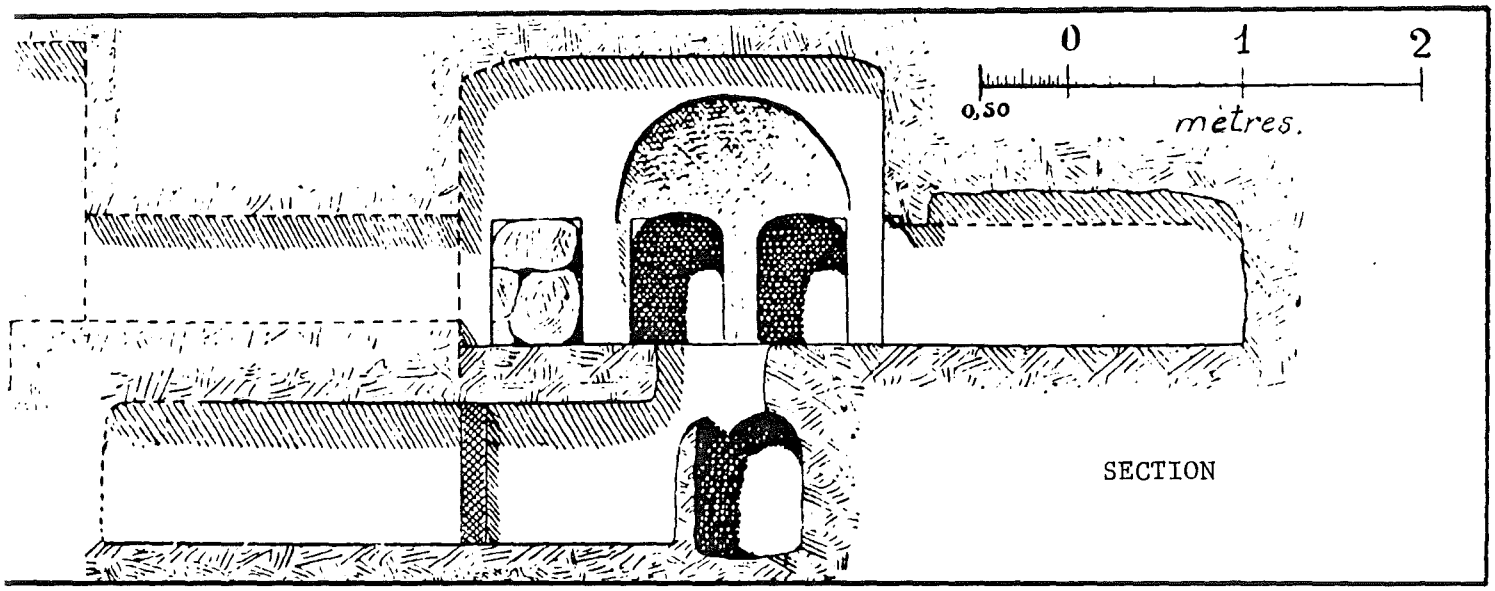


Figure 2. The modern remains of the Holy Sepulchre showing the tomb of Joseph of Arimathea behind it.



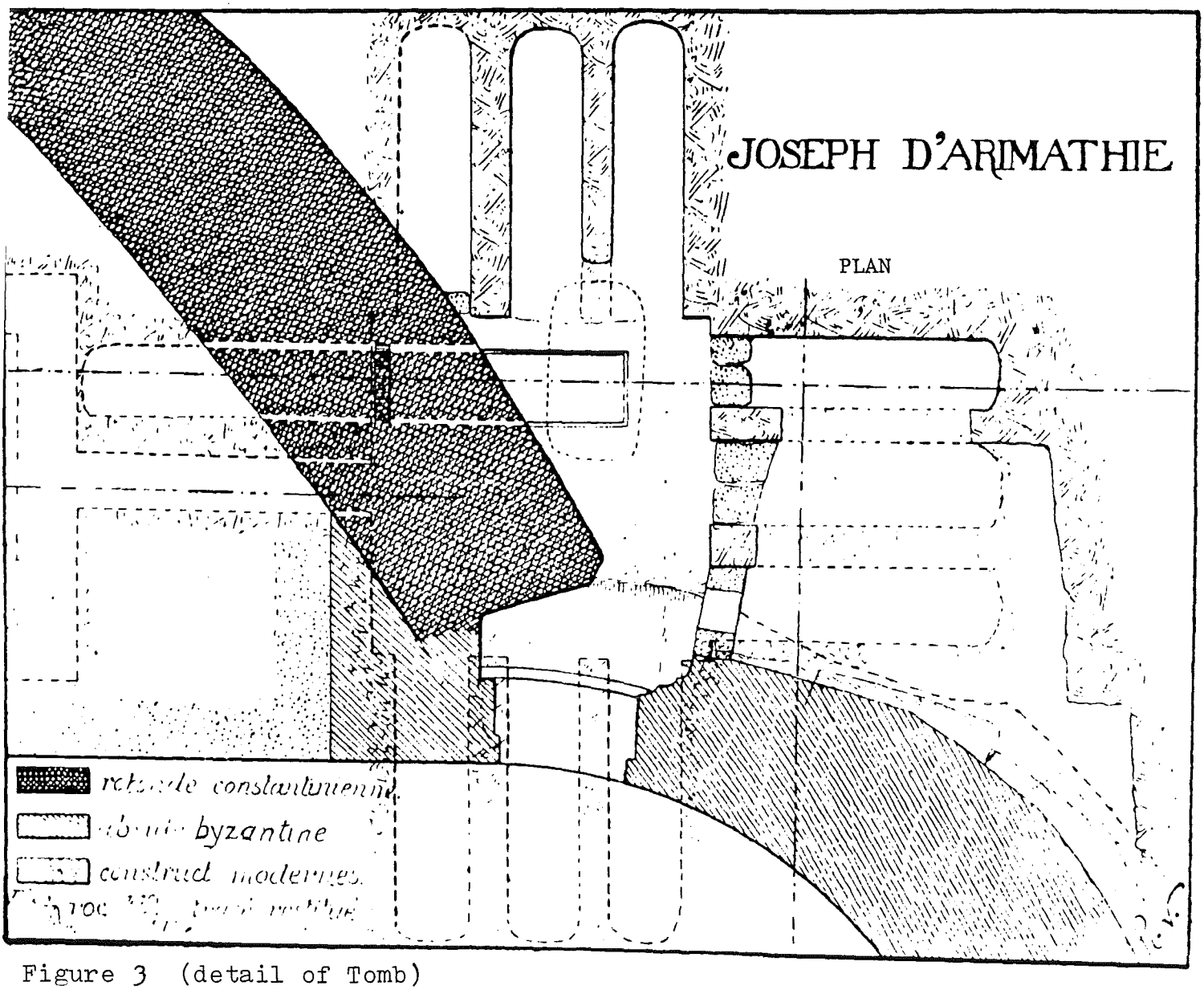
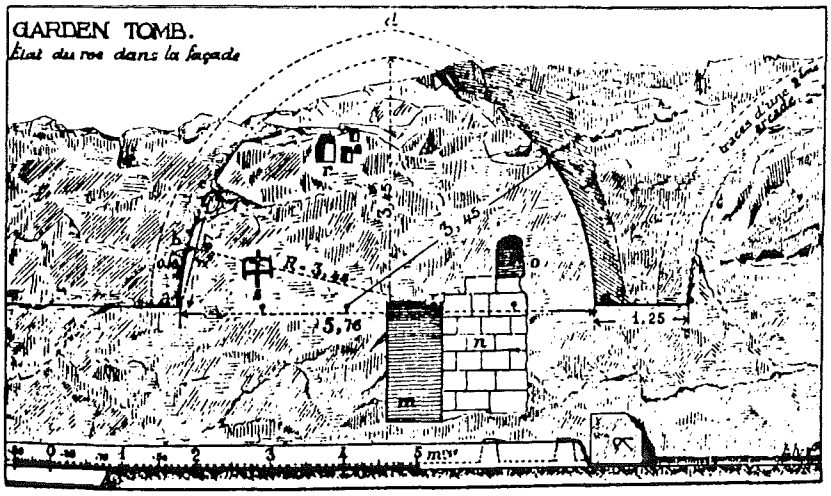
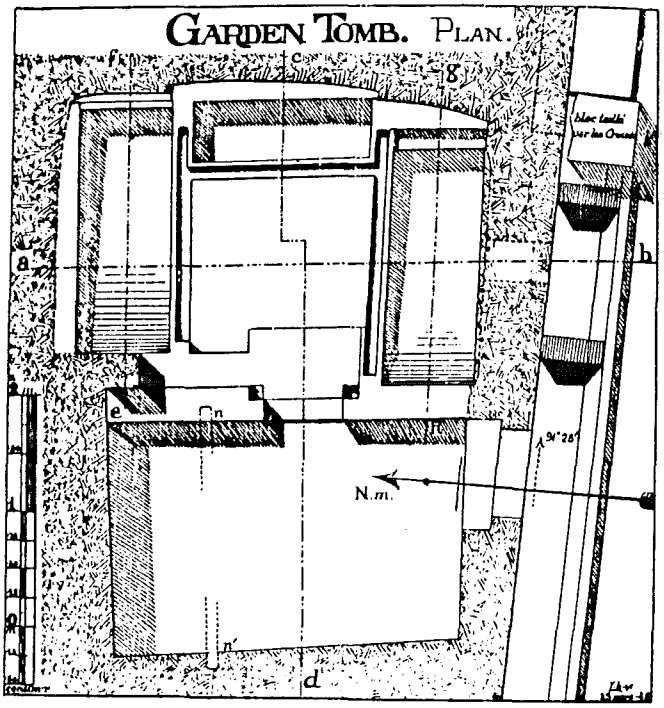


Figure 3 (detail of Tomb)


GARDEN TOMB.
État du roc dans la façade
5,76
1,25
5 mètres


GARDEN TOMB. PLAN.
N.m.

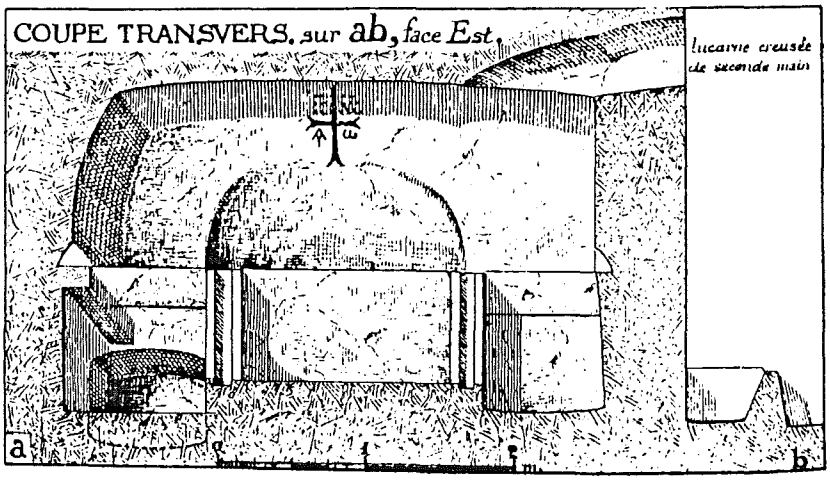

COUPE TRANSVERS. sur ab, face Est.
Lucarne creusée de seconde main

Figure 4

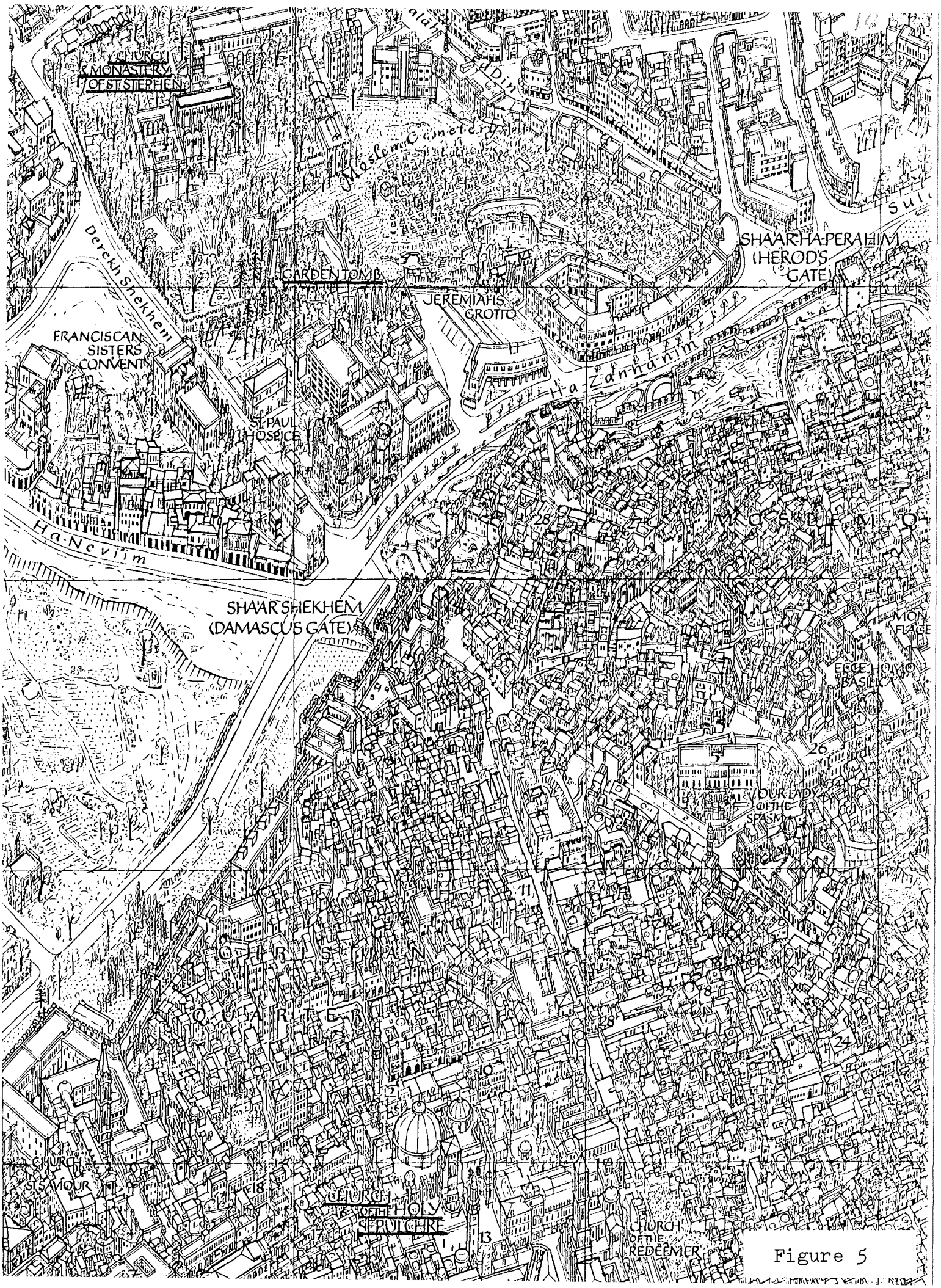

CHURCH & MONASTERY OF ST. STEPHEN
Muslim Cemetery
Derekh Shekhem
GARDEN TOMB
JEREMIAHS GROTTO
SHAAR HA-PERAHIM (HEROD'S GATE)
FRANCISCAN SISTERS CONVENT
ST. PAUL HOSPICE
Ha-Zanhanim
Ha-Nevim
SHAAR SHEKHEM (DAMASCUS GATE)
MONASTERY OF THE FLAGE
ECCE HOMO BASILICA
OUR LADY OF THE SPASM
CHRISTIAN QUARTER
CHURCH OF THE HOLY SEPULCHRE
CHURCH OF THE REDEEMER
CHURCH OF THE SAVIOUR

Figure 5

CHAPTER 1

THE MYLAR TAPES

In September, 1982, Dr. Ray N. Rogers of the Los Alamos National Laboratory provided Joseph Kohlbeck with some of the Mylar tape samples which he made during the 1978 scientific examination of the Shroud in Turin. Kohlbeck was asked to take photomicrographs of the samples, which were made on a 4x5 Veri-Color three negative film using the Leitz Ortho Lux I Pol microscope and a 100x oil immersion objective. Color prints were then made on a 8x10 format which increased the total magnification to 2500x with excellent resolution.

When examined microscopically, image area samples contained a number of yellow fibers among those which were colorless, Figure 6. Colored fibers were generally not found in non-image areas. Not all fibers are uniformly colored throughout. Some have only a portion colored. At times this was the central portion; at other times an edge or a portion of an edge. These yellow fibers from the Shroud show a faint pleochroism, green or yellow north-south and gray or white east-west. Pleochroism is the property of a crystal of displaying colors when viewed by light that vibrates parallel to different axes.

When fibers from image areas are examined in cross-polarized light, many show a higher polarization color, white versus gray at the edges of the fiber and sometimes only at one edge. Possibly these fibers are thicker in these areas which would explain the increase in polariztion color; but there could be other reasons, such as absorbtion of some material.

In plane polarized light, certain areas within colored fibers absorb more light than other areas of the same fiber. This is best seen using monochromatic light. There are darker areas within these fibers and rotation of the stage does not relieve this differential absorbtion. These areas are not believed to be due to any crystallographic cause.

There were several other types of fibers found in these slides which are foreign, undoubtedly the result of contamination during early expositions, storage cloths, and any number of other sources.

Certain fibers from blood areas have red particles ranging in

size, such as those from the lance wound area, Figures 8, 9, 13. Clusters of about ten microns to individual particles from two microns to about seven-tenths of a micron are common. Closer examination of the fibers at higher magnifications (1250x) show there are many of these particles which are colorless to light yellow, which are the same size and shape as the red particles. The photomicrograph in Figure 14 is representative of fibers from the wrist wound area and shows the particles just described. Occasionally, larger clusters of red particles are found off the fibers, but in close proximity to the fiber.

In early December of 1982, permission was granted to Kohlbeck from Rogers to remove some of the fibers from the lance wound area tape for further observation without interference from the Mylar tape, Figures 8, 9, 13. Several days were spent carefully washing the adhesive from a small tape sample with reagent grade toluene. Those fibers which were colored retained their color and the pleochroic property could be seen more clearly. Not all fibers which contained red particles were colored; some were colorless. The reddish particles were unaffected by the toluene wash and generally continued to adhere to the fibers. However, there were a few clusters which broke off from the fibers during handling. Five slides of the washed fibers were prepared; two in OV-17, a silicone oil stable to 350°C, and three in Cargille Type A immersion oil 1.515. The three slides mounted in Cargille oil were photographed, but did not give any additional information at this time except for a sharper image. The two slides prepared in OV-17 were heated on a hot stage to 350°C. Most of the particles adhering to the fibers darkened, as did the fibers and not a great deal was learned from heating except that there was a change. No further observations were made on the fibers mounted in Cargille oil for two and one-half months. One weekend in the middle of March, these slides were observed again and there was a pronounced change noted in the red particles. Most were no longer red, but black and there was a yellow exuding from the now black particles, see Figures 10, 11, 12. Further examination of the black particles showed what appears to be a cluster of cell-like structures where there was once a cluster of red particles. Those particles which were measured to be one or two microns in diameter ap-

peared to have a nucleus. They do not; however, this apparent nucleus continued to change to a colorless particle with time and was difficult to see by the end of May. Many of the particles had become mobile and were elsewhere in the preparation and difficult to find. During these observations, several clusters which had been removed from the fiber appeared to contain hundreds of cells together. These clusters were impossible to photograph because only a small section at a time could be brought into focus. Based on these observations, the red particles shown in Figures 8 through 12 are organic and not iron oxide. Absolute identification cannot be made at this time, but the possibility exists that these particles are blood-related as reported by John Heller and Alan Adler.(1) Heller and Adler reported the presence of blood earlier using chemical tests. The changes in red particles seen here were unexpected and if what has been observed is truly blood, this procedure has certainly not been used previously. Going back for a closer microscopical examination of blood areas from the original samples showed numerous colorless or slightly yellow particles which may have originally been red and undergone a change similar to the changes noted in this study. Re-examination of the samples showed that particulates were present in all colors from colorless to black with red being the predominant color, Figures 15 and 16. A very important point now becomes apparent, perhaps the change noted here also occurred on the Shroud at a much slower rate and perhaps that change is still occurring. These observations suggest that however slight, the Shroud of Turin is a dynamic rather than static system. To our knowledge, this is the first time anyone has suggested or demonstrated a change and has actually photographed it.

In May of 1985, I received the Mylar tapes(2) on loan for comparative study and photography. My research was to provide both an archaeological context and recommendations in conservation, two fields in which I have previous professional experience.

Upon earlier examination of the Mylar tapes, Dr. Walter McCrone of the McCrone Research Institute, declared that the red particles observed adhering to the flax fibers on the Shroud were not blood, but rather iron oxide,(3) as could be found in red paint, hinting at the work of an artist or forger. McCrone then proceeded to demon-

strate a non-brush stroke technique by having iron oxide finger-painted onto linen.

McCrone's iron oxide particles show an even red coloration throughout which cannot be affected by age, Figures 24 and 25. Kohlbeck on the other hand, photographed the Shroud's particles in a variety of colors ranging from black, red, yellow, and colorless, Figures 13 to 16. McCrone's iron oxide particles also show a uniformity in size, unlike most of the red particles on the Shroud. Studies of blood cells in Egyptian mummies show that there is a variation in size present in those cells which had caused their misidentification for many years.(4)

I began noticing another problem with McCrone's iron oxide finger-painting theory. Through the microscope, the iron oxide particles as viewed on McCrone's slides were fairly loose particles which did exhibit directional strokes across fibers, Figures 24 and 25. The Shroud's particles, on the other hand, clustered more often, Figure 23, and showed no directional patterns across fibers, Figure 22, but only when the tape had lifted the particles off their lengthwise encrustation of a fiber, Figures 20 and 21, was any directional pattern noticed. It was further observed in a massive photographic cataloging project by me,(5) of all the significant items to be viewed on the tapes, that there are proportionately not enough particle-covered fibers to produce image, Figure 7. Our experimentation agrees with STURP's view that the image is created by a change within the cellulose of the flax.(6) Location of red particles is not necessarily indicative of their being non-blood related, since as our Jerusalem Test Cloth 4 illustrates (Chapter 2), the repeated folding and unfolding of the cloth, as with the Shroud, causes the relocation of loose materials. Figures 17 through 19 show further various groupings and clusters of red particles as observed on Shroud Mylar tapes from frontal and dorsal areas.

If red paint can be found, there are two possible explanations: during the time of Christ, aside from infrequent use of frescos, various colors of paint were used at the time of interment or the traditional reburial of skeletal remains.(7) Quite often an inscription concerning the dead was written in red paint above the niche, or kokh, where the body was to be laid (see Figure 31). Blue paint

was used over earthen graves of the poor to warn people that a dead body was there and the area unclean. Yellow was often used on ossuaries. Rachel Hachlili and Ann Killebrew noted during their excavation of tombs from the Early Roman or Second Temple period:

> Red paint, found on the front, sides and lids of the Jericho ossuaries, may be related to the Greek 'magical' practice of painting the inside of stone or clay sarcophagai red. The color red was sometimes used to symbolize blood or fire.(8)

A possibility for paint contamination on the Shroud could result from the action of a member of the burial party whose haste to finish before the Sabbath, dripped paint down onto the shrouded body on the bench (see Figure 31 for proximity). It has also been found by Don Luigi Fossati that medieval copies of the Shroud were laid on top of the Shroud to produce "touch relics" and could have been a source of some types of paint contamination.(9)

Other materials have become evident, such as myrrh, aloes, and calcium, which will be discussed in succeeding chapters. From the dorsal image area at the small of the back, a red fragment was found which seems to have the fibrous structure of muscle, Figure 26. When compared to fresh muscle samples the similarity is quite striking and warrants further investigation. The main difference which is immediately evident in this comparison, like that between the Shroud's red particles and fresh blood cells, Shroud fibers and modern fibers, is the difference in size, all samples from the Shroud being much smaller. But this is due quite simply to the process of dehydration. On the Shroud, dehydration has and is taking place on at least three different levels: The initial drying, as with blood, at the time of burial; continued moisture loss with age, such as 2000 years; and, that effected by the cathedral fire of 1532.

Figure 29 shows another previously unrecorded contaminant to the cloth, a human hair, which, like other samples, is smaller in diameter than its modern counterpart.

REFERENCES

(1) John H. Heller and Alan D. Adler, "A Chemical Investigation of the Shroud of Turin," Canadian Society of Forensic Science Journal, Vol. 14, No. 3 (1981), pp. 81-103.

(2) The Mylar tapes which I have observed and photographed are:

Frontal ("F" suffix)	Dorsal ("B" suffix)
1BF	1AB
1FH (Holland cloth patch)	1DB
2AF	1EB
3AF	1GB
3BF	1HB
3EF	1IB
6AF	1JB
6BF	3BB
6DF	4EB
9BF	
9CF	

And samples from Walter McCrone which were included with the Shroud mylar tapes: #1 to #4 marked "Fe_2O_3 on linen;" one marked "Shroud wax" which was blank; one marked "Fe_2O_3 & Fibers;" one marked "Contaminant Frame 3;" one marked "Miria's Blood;" one marked "Aloe;" and, one marked "Mirra."

For other lists of the Mylar tapes taken, see also: Walter C. McCrone and Christine Skirius, "Light Microscopical Study of the Turin 'Shroud' I," The Microscope, 28 (1980), pp. 105-128; and, Heller and Adler, Can. Soc. Forensic Sci. J., pp. 81-103.

(3) McCrone and Skirius, Microscope, p. 105.

(4) Michael R. Zimmerman, "Blood Cells Preserved in a Mummy 2000 Years Old," Science, Vol. 180 (April, 1973), pp. 303-304.

(5) Sister Damian of the Cross, OCD, A Photographic Catalogue of the Mylar Tape Samples Taken from the Shroud of Turin in 1978 (February 21, 1986).

(6) L.A. Schwalbe and R.N. Rogers, "Physics and Chemistry of the Shroud of Turin: A Summary of the 1978 Investigation," Analytica Chimica Acta, Vol. 135 (1982), p. 44.

(7) Julius Jotham-Rothschild, "The Tombs of the Sanhedria," PEQ (January-April, 1952) pp. 23-38; N. Avigad, "Excavations at Beth She'arim, 1953," IEJ, Vol. 4 (1954), pp. 88-107; Avigad, "Excavations at Beth

She'arim, 1954," IEJ, Vol. 5 (1955), pp. 205-239; E.L. Sukenik, "The Earliest Records of Christianity," AJA, Vol. 51 (1947), pp. 351-365.

⑧ Rachel Hachlili and Ann Killebrew, "Jewish Funerary Customs During the Second Temple Period, in the Light of the Excavations at the Jericho Necropolis, " PEQ, 115 (1983), p. 127.

⑨ Luigi Fossati, SDB, "Copies of the Holy Shroud," Shroud Spectrum International, Part 1, No. 12 (September, 1984), pp. 7-23; Parts II and III, No. 13 (December, 1984), pp. 23-39.

Figure 6, Mylar tape sample 3BF. The darke fibers are image, while the lighter are non-image. Taken at 625x by Kohlbeck.

Figure 7, Mylar tape sample 6AF. Particles on fibers from the lance wound area. Taken at 313x by Kohlbeck.

Figure 8, sample 6BF from the lance wound area. Red particles on top of the fiber. 650x by Kohlbeck.

Figure 9, sample 6BF from the lance wound area. Red particles on Mylar tape before being remounted in Cargille oil. 650x by Kohlbeck.

Figure 10 (left) sample 6BF after 2½ months in Cargille oil. The red particles have turned black and a yellow substance is exuding from the particles. 650x by Kohlbeck.

Figure 11 (right) same sample, different view. 650x by Kohlbeck.

Figure 12, same sample as Figures 10 and 11 above, different view. 650x by Kohlbeck.

Figure 13, sample 6BF showing red particles. taken at over 700x by Kohlbeck.

Figure 14, sample 3EF from the wrist wound area showing yellow and colorless particles on a fiber. 650x by Kohlbeck.

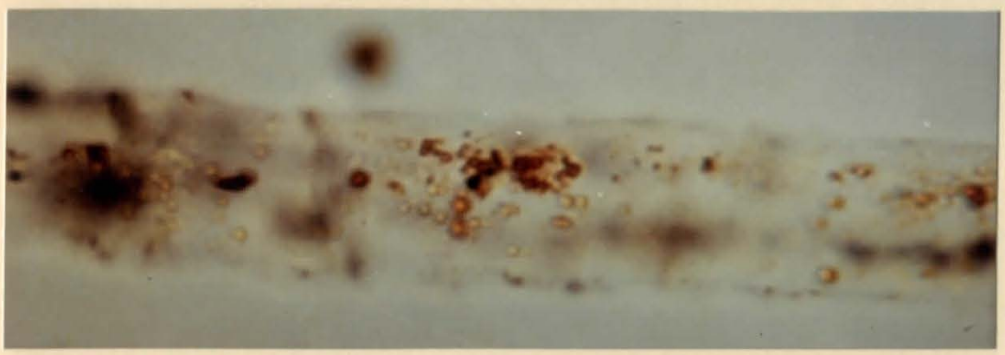


Figure 15, sample 6BF showing variations in particle color of red, black, yellow, and colorless. 650x by Kohlbeck.

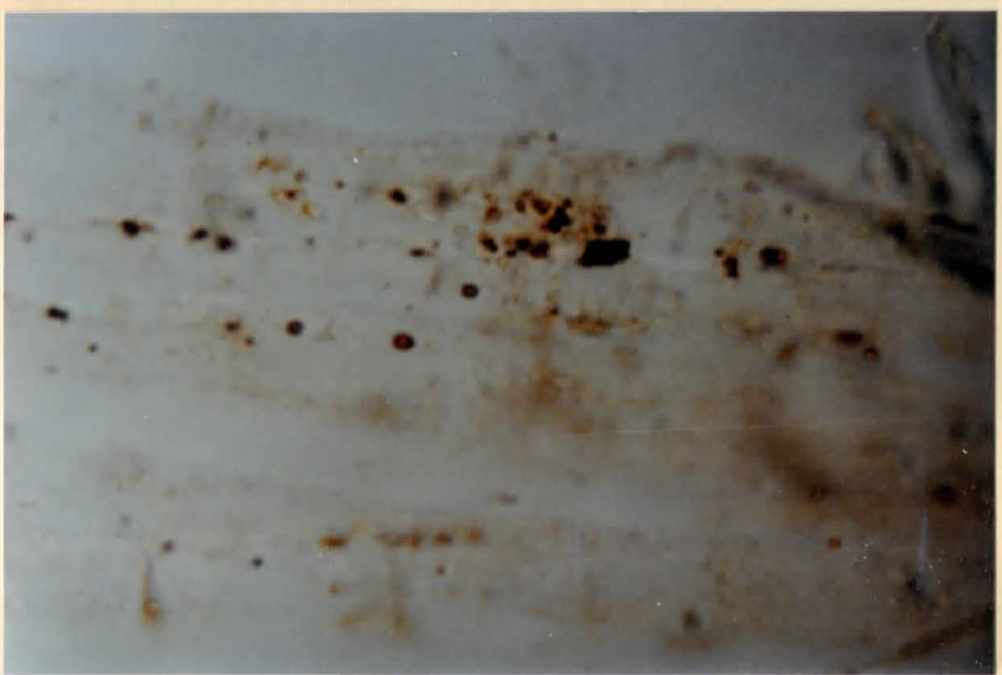


Figure 16, sample 6BF illustrating particle colors as in Figure 15. 650x by Kohlbeck.

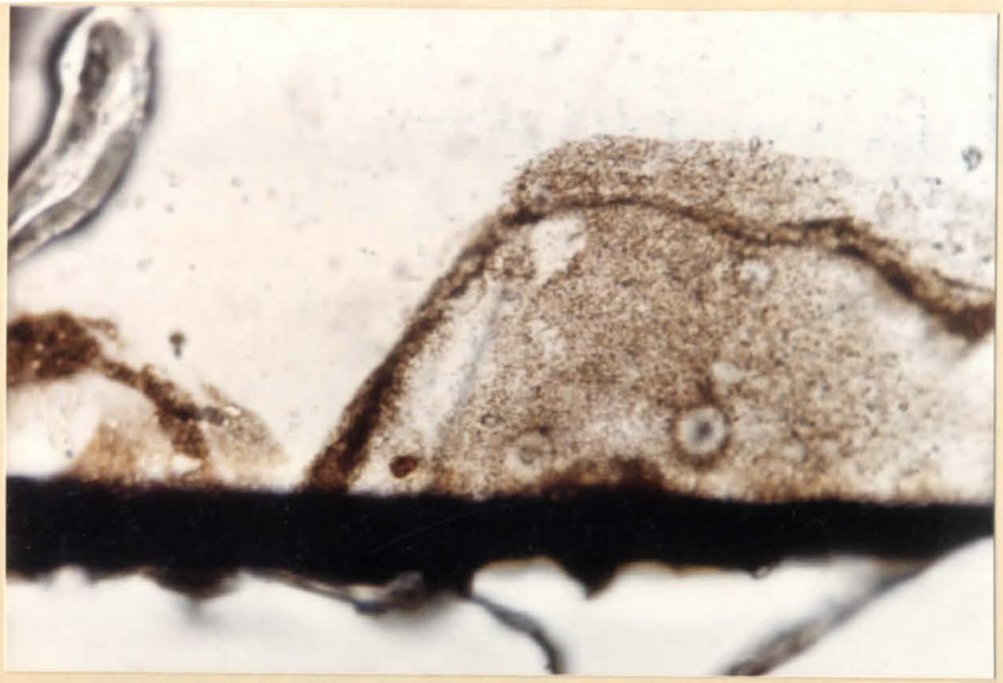


Figure 17, sample 1FH from a frontal Holland cloth patch. A group of red particles. 313x by Kohlbeck.

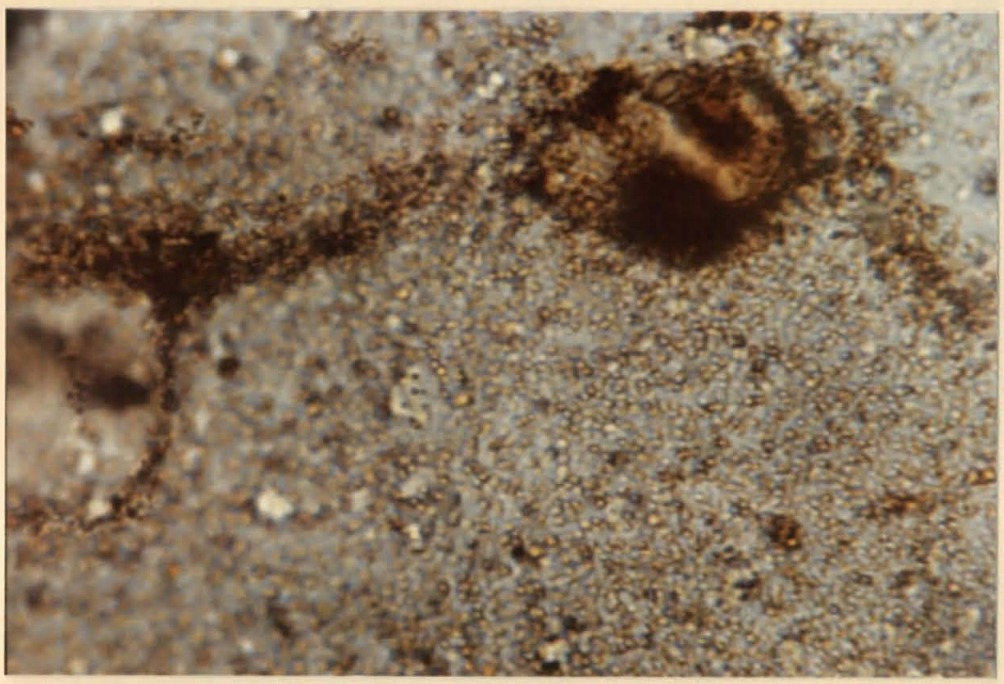


Figure 18, sample 1FH, a detail of Figure 17, taken at 625x by Kohlbeck.

Figure 19, sample 4EB from the dorsal image shoulder area. A cluster of black particles. 400x by Damian.

Figure 20, sample 1DB from the bloody foot area. A partilce pattern taken at 100x by Damian.

Figure 21, sample 3AF from the tips of the fingers, a particle pattern taken at 100x by Damian.

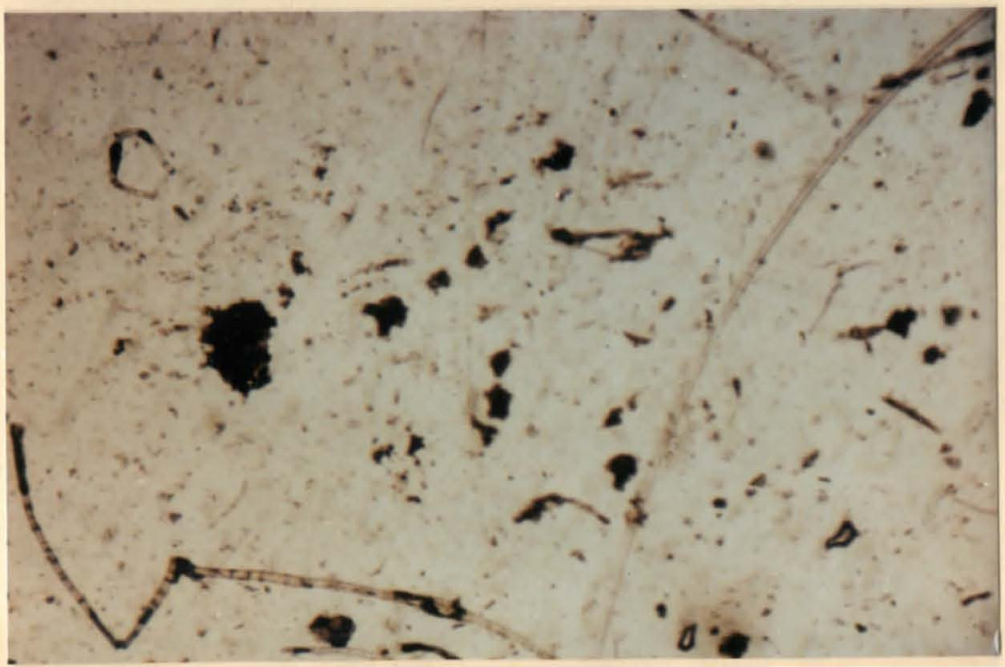


Figure 22, sample 1EB from the dorsal image lower calf of leg near the ankle, a particle pattern taken at 40x by Damian.

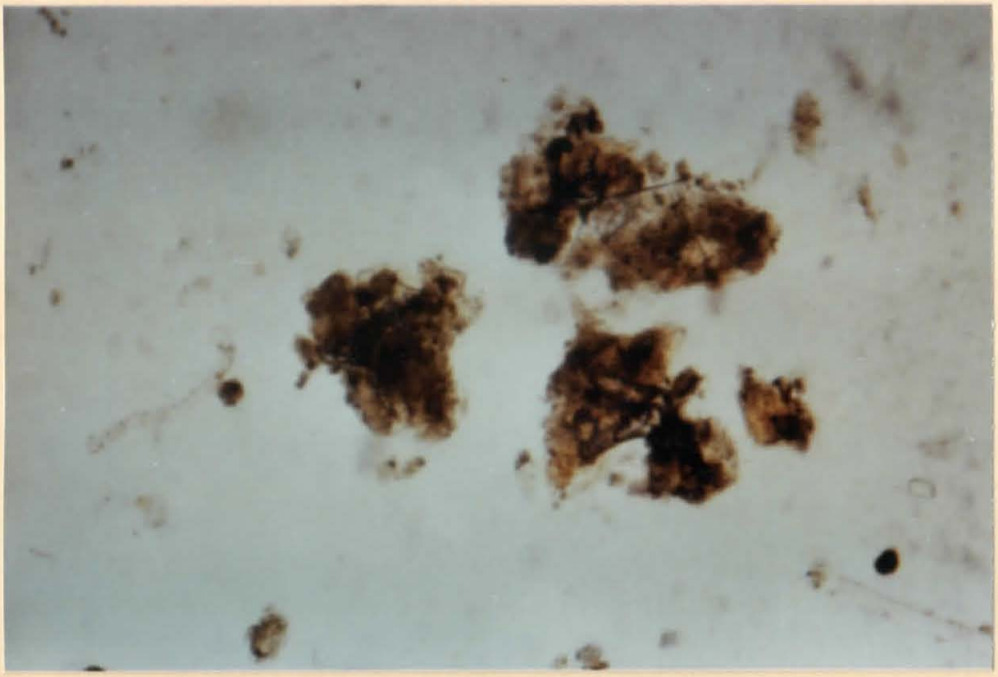


Figure 23, sample 1EB. Clusters of particles taken at 100x by Damian.

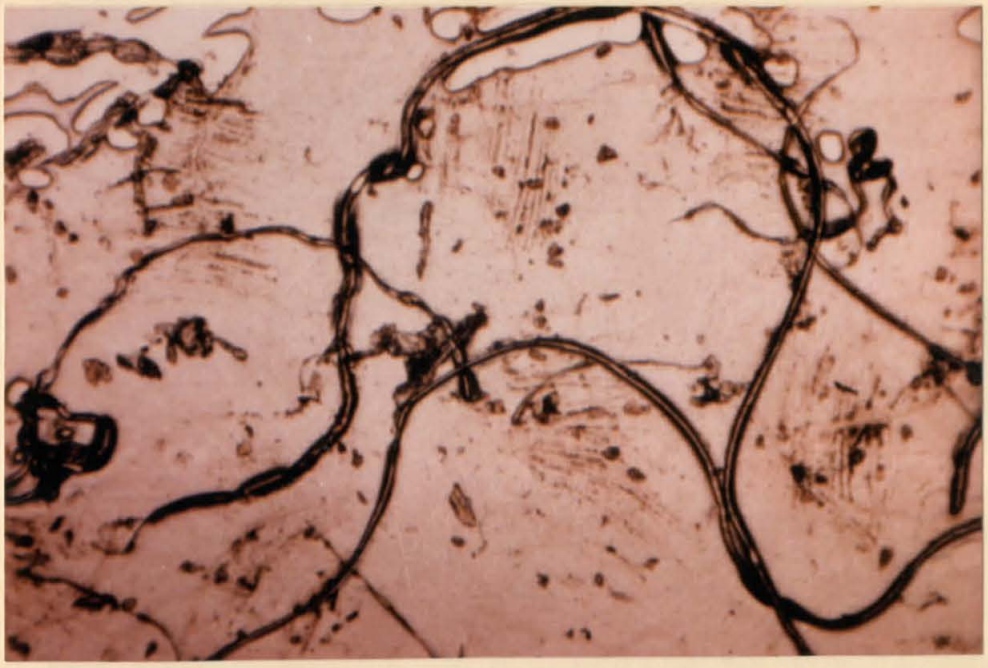


Figure 24, McCrone's "Fe_2O_3 on Linen" taken at 40x by Damian.

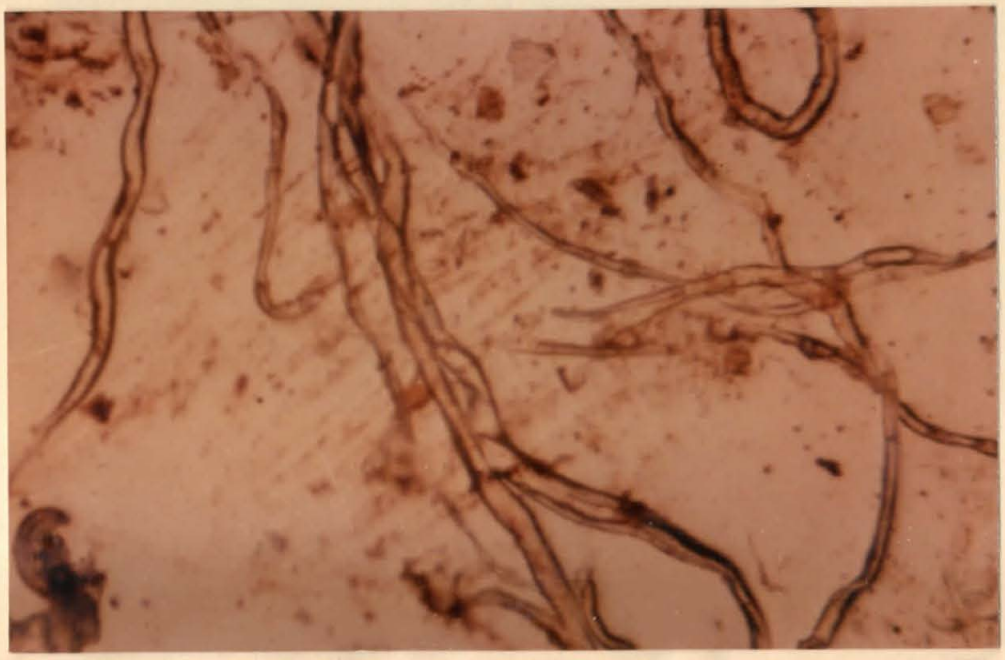


Figure 25, McCrone's "Fe_2O_3 on Linen" taken at 100x by Damian.

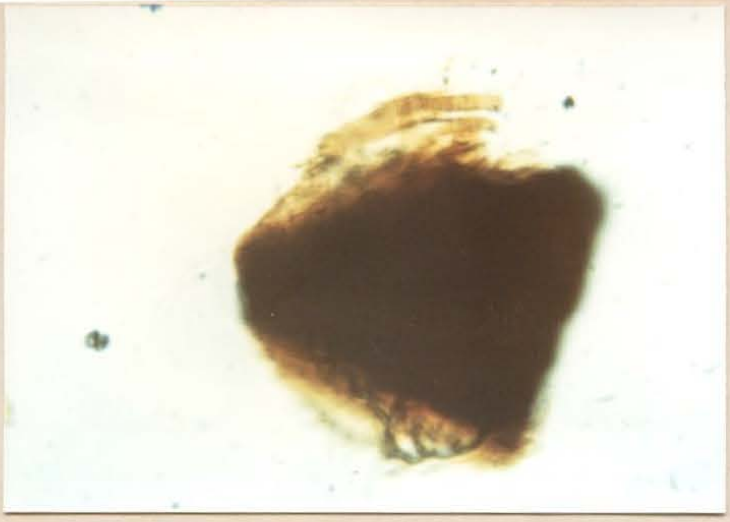


Figure 26, sample 3BB from the dorsal image lower back, possible muscle fragment taken at 650x by Kohlbeck.

Figure 27, fresh muscle sample taken at 40x by Damian.

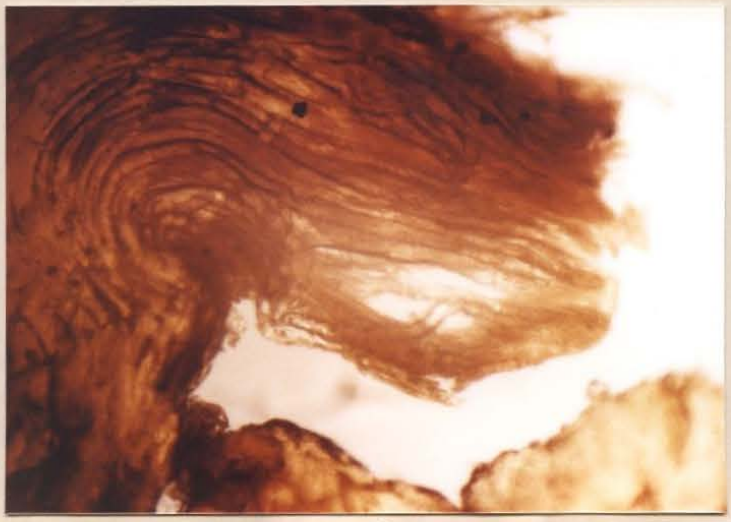


Figure 28, fresh muscle sample taken at 40x by Damian.

Figure 28, sample 1BF, human hair taken at 400x by Damian.

CHAPTER 2

FIELD DATA AND ANALYSIS

To begin a study of the origin of the Shroud's image requires a knowledge of both the changes which occur in the body at death and the environment of the tomb. Our detailed research in both these areas led to a naturalistic explanation for image formation.

Physicians and pathologists have written numerous books and articles[1] about the possible cause for the death of Christ, but have offered little by way of the step by step effects of death on the body. For this reason, I not only consulted books on forensic pathology, but also morticians and their textbooks on embalming. I was surprised at the different ways in which the two disciplines view those changes. These differences are due, in fact, to the way in which each must either treat the body or gain information from it. The forensic pathologist is concerned with cause and time of death, while the mortician immediately involves himself with stabilizing the body for the sake of preservation and appearance. An appropriate example would be the variations in the pH factor in the body at death, as well as during and after rigor mortis. Upon examination of a textbook on embalming, the full range of pH values was given. The forensic pathologist has little need to discuss the body's acidity or alkalinity after death, while to the mortician, it is paramount in preventing decomposition.

For this reason, I will list all those changes, beginning before death in a traumatic situation, through death until the point in which rigor mortis leaves the body. This will not only provide the reasoning behind our experimentation, but also make the material available to other researchers in a far more convenient form. Since the implication is that the Shroud contained the body of Christ, we will assume the events of crucifixion and those which immediately preceded it as related to Christ.

CHANGES IN THE BODY BEFORE DEATH Little attention has been given to the heat generated by a body which has undergone hematidrosis (bloody sweat), scourging, and crucifixion. In each case, loss of body fluids (blood and sweat), lack of fluid intake, lack of rest,

and extreme physical exhertion, would lead to severe dehydration which in turn raises the body's temperature. Severe trauma or emotional stress produces an acidic condition in both blood and perspiration.

In a study of heatstroke victims made in Israel between 1956 and 1966,(2) a number of interesting and highly explanitory correlations our research can be drawn. Thirty-six male patients, between the ages of 17 and 24 were clinically observed after the onset of the illness. Contrary to popular opinions, heatstroke sometimes occurred under comparatively mild environmental conditions, for example, in the early morning of a relatively cool day. The primary cause of heatstroke is the body's inability to dissipate accumulated body heat by sweating, rest, and fluid intake. Excessive body temperature and not atmospheric temperature is the cause of heatstroke. Common factors among nine fatal cases were: strenuous physical activity, lack of sleep, lack of fluid intake, and profuse sweating. Contrary to popular belief, sweating does not cease during heatstroke, and such an assumption has led to the misdiagnosis of the illness.(3)

The most prominent finding in the autopsy reports of the fatal cases were: acidosis of the blood; disturbances in blood coagulation, which resulted in severe hemorrhaging in the brain, kidneys, liver, adrenals, lungs, and skeletal muscles; pulmonary congestion; pulmonary edema; congestion in the spleen; and, widespread cellular degeneration. Body temperature generally exceeded 42°C (about 108°F) at the moment of collapse and the shivering and convulsions produced were found to increase the metabolic heat load.

Dr. Pierre Barbet recorded the eye-witness accounts of two prisoners at Dachau of those who had been condemned to death by being hung by their hands and whose feet were not allowed to touch the ground: "A profuse sweat appeared all over the body, dropping down to the ground and staining the cement. This sweat was especially abundant, indeed to an extraordinary extent, during the last few minutes before death; the hair and beard were literally drenched. And this, though the temperature was at freezing point. The dying man must have had a high temperature."(4)

The parallels between Dachau and the heatstroke victims studied in Israel and the trauma Christ endured before(5) and during crucifixio

are staggering. It may provide a solution for the onslaught of the sudden death of Christ during the crucifixion.(6) The current challenge Dr. Zugibe(7) has made to Dr. Barbet's conclusion that death during crucifixion is induced by asphyxiation, whether tenable or not, may now meet with difficulty, if heatstroke in the case of Christ can be offered as a viable possibility. From the agony in the Garden beginning Thursday evening, to His death on the cross Friday afternoon, Christ suffered severe dehydration from sweating, blood loss, and lack of fluid intake, which was compounded by lack of sleep and extreme physical exhertion. If these conditions overloaded His body's ability to dissipate the high temperatures produced and heatstroke was induced, a new list of agonies can be added to those already known.

CHANGES IN THE BODY AT DEATH The following is a synthesis of sources from both forensic pathologists and morticians.

(1) The Eyes. One of the first changes to take place in the body at death is the sinking and flattening of the eyes.(8) This is of tremendous importance with regard to the facial image on the Shroud and the possibility of the placement of coins on the eyes. If the eyes will flatten and sink, there is no way the area of the eyes could be seen on the Shroud or by the VP8 image analyzer, unless objects of some sort had been placed on them (see Chapter 7).

(2) Temperature. While the possibility of heatstroke has already been discussed, a temperature rise after death can occur and while there is no term for it in the medical field, it is called post mortem caloricity or post mortem fever by morticians.(9)

There may be an ante mortem drop in temperature in the distal parts of the body when the agonal period is prolonged. Thus, the hands and feet of an individual are cold to the touch before death occurs. Under ordinary conditions, the dead human body, unprotected by clothing, blankets, etc., cools at the rate of about 4°F per hour for the first few hours, and then drops to a rate of about 1°F per hour. The temperature of the interior of the body equals that of the exterior in about 40 hours after death.

"In some cases there may be an abnormal rise in the body temperature following death (even to levels as high as 110°F)."(10) This condition is due to the continuation of chemical activity within the cells, when the body's cooling system - respiration and per-

spiration - have ceased.[11]

To add a rise in the body's temperature from 1° to 11° to the temperatures ranging from 98.6°F (normal) to 108°F (beginning of heatstroke), could set an upward limit after death of 99.6°F to 119°F. Such high temperatures are not unknown, since in July 1986, during the heatwave which hit the southern United States, a man died with a temperature of 112°F.[12]

(3) Rigor Mortis. Rigor mortis[13] is a post mortem stiffening of the muscles. It seems to be caused by the release of lactic acid in the body (see under #5, pH). At the moment of death, the muscles relax completely. The lower jaw drops and the limbs become flaccid. Rigor appears first in the involuntary muscles such as the heart and arteri It usually affects the voluntary muscles within 12 hours after death, although in cases of violent death it may appear within minutes. After violent muscular exercise, death is quickly followed by rigor mortis. When convulsions precede death, rigidity may appear quickly and last for several days. The usual course of appearance is the eyes, back of the neck and lower jaw, face, front of the neck, chest and upper extremities, trunk, and last of all, the lower extremities. In most cases it leaves in the same order, the body becoming quite flaccid and rigor never returning. Rigor usually lasts from 10 to 72 hours. Ordinarily, it begins to disappear in about 38 hours in summer and from 48 to 62 hours in winter, but much depends on cause of death and environment; accelerated by heat and retarded by cold. The acidic condition caused by rigor mortis prevents decomposition from beginning. When rigor leaves, however, the body's chemistry becomes an alkaline and decomposition begins.

The violent death suffered by Christ on the cross would have caused the immediate appearance of rigor mortis, causing His body to remain in the shape it had taken while still on the cross, see Figure 31. This has been aptly detected by Monsignor Ricci from his study of the image on the Shroud.[14]

The use of the chin band and the positioning of the arms with hands crossed over the pelvis have often been questioned, to which the following may suffice as an explanation. Since all the muscles of the body relax immediately at death, Christ's jaw could have opened before the sudden appearance of rigor mortis as in violent

death. When His body was removed from the cross, at least an hour after death when permission was sought from Pilate, the shape the body had taken from the cross, namely arms extended, would make burial in the tomb, and even entry through the narrow doorway (.50m wide and 1m high) impossible (see Chapter 4). The body had to be somewhat prepared outside the tomb. The jaw could have been closed and the arms bent from the shoulders, however, once any joint stiffened by muscular contraction is forcibly bent, rigidity is destroyed. A chin strap or band and the tying of the wrists would then be required or the position of either could not be held. The Mishnah, Shabbath 23:5 says, concerning such preparations permissible on the Sabbath:

> They may make ready [on the Sabbath] all that is needful for the dead, and anoint it and wash it, provided that they do not move any member of it. They may draw the mattress away from beneath it and let it lie on sand that it may be the longer preserved; they may bind up the chin, not in order to raise it but that it may not sink lower.

Since Christ was placed in the tomb before the Sabbath, the chin could have been raised and the body moved. This may be the origin of the "stone of anointing," near the edicule within the Church of the Holy Sepulchre.(15) A place not used for the actual preparation of Christ's body, but rather the preliminaries to its placement in the tomb.

(4) Blood Chemistry. The blood stains on the Shroud, especially the formation of clots, has been a topic of great debate and research.(16) Several conditions of the blood prior to death have already been discussed in regard to heatstroke, namely, acidosis and the breakdown of the coagulation system. Blood has the ability to coagulate readily only when at a temperature which approximates or exceeds that of the normal living body. Blood kept at a low temperature does not coagulate at all. It is very probable that, under certain conditions, there will be no more clots in a body six hours after death than there were two hours after death.(17) Chemical amounts in blood are affected in the following way:(18)

Glucose	-rise.
Lactic acid	-sharp rise.
Urea nitrogen	-constant.
Creatine	-constant.
Ammonia	-sharp rise.
Uric acid	-rise.

Bilirubin	-rise.
Protein	-constant.
Enzymes	-rise.
Sodium	-slight decrease.
Chloride	-slight decrease.
Potassium	-rapid rise.
Calcium	-constant.
Phosphorus	-rise.
Sulfur	-constant.
Magnesium	-mild rise.

There is an increasing acidity of the blood after death. The pH averages from 6.73 for the first 12 hours post mortem and 6.43 for the next 12 hours.

(5) Sweat Composition. The composition of sweat during trauma or stress is markedly different than that under normal conditions.[19] A rise in values can, of course, only be taken during life. For our purposes, only two levels can be documented: normal sweating opposed to sweating linked with heat illness and stress, being affected in the following way:

Sodium	-somewhat constant.
Chloride	-constant.
Potassium	-rise.
Magnesium	-rise.
Lactic acid	-rise.

(6) pH (Hydrogen Ion Concentration). Both blood and sweat go through an acidic change during trauma and stress. Normal human blood pH has a range of 7.35 to 7.45 and variations of only 0.2 pH units beyond this can cause serious illness and even death. The presence of rigor mortis also causes a change in the body's pH, which can be listed as follows:

Condition of the body	pH of body
1-primary flaccidity at death	=neutral or faintly alkaline (7.4)
2-moderate rigidity, beginning of rigor	=mildly acid
3-maximum rigidity	=strongly acid, 6.6(6.3)[20] or 6.43[21]
4-moderate rigidity, rigor begins to leave	=mildly acid
5-secondary flaccidity, rigor gone	=alkaline

A NATURAL MECHANISM FOR IMAGE FORMATION Most of the tests and theories about image formation have dealt with the frontal image of the body with neglect to the dorsal. The inequality of clarity and definition of the two have not been discussed in depth, nor

hardly mentioned except by those whose aim is to prove the Shroud a forgery.(22)

From past examinations of the Shroud we know the image is not a painting. The image was not created by a dye, stain, pigment,(23) or scorching technique.(24) But the list of negatives should be carried further, especially in regard to the inequality of frontal and dorsal clarity and definition. Weight cannot be a factor in image production.(25) If weight were a factor, the dorsal image should be as clear as the front. The back, on the contrary, is a faint blur with the main constituent being blood. Because of the condition of the dorsal image, a 3-D image of the back cannot be produced to equal the front. I also maintain that weight is not a hinderence to image formation, but enters only indirectly as being that force which applies the Shrouded body against the limestone bench of the tomb causing a a slowing of the image process because of the cold stone.

Figure 32 is the dorsal image of the Shroud. The red dotted lines enhance alternating bands of light and dark image-blood areas. When compared to Figure 31, the body in rigor mortis from the cross, a correlation between the light and dark bands with those areas of the body which either touch or do not touch the bench can be made. If there is an inequality in frontal and dorsal images on the Shroud, and if there are alternating bands of dark and light image within the dorsal side of the Shroud, this would seem to lead to a natural explanation for the formation of the image. A natural image mechanism would be subject to environmental conditions in the tomb when a supernatural process would not.

The image on the Shroud of Turin has been described as the dehydration of the cellulose of the flax fibers,(26) resembling a mild scorch. The one factor missing in all previous image experiments has been the heat of the body. Those who have used cadavers or simulated body forms(27) in their experiments have neglected to apply the heat which would be expended slowly by a newly dead body. As previously discussed, the heat generated by a body in traumatic death, possibly involving heatstroke, in addition to post mortem fever could place the body's temperature as high as 119°F. The high acidity of the body in reaction to the alkalinity of the limestone tomb (pH 8.0 to 8.5, see Chapter 3) being accelerated by the heat of the body can breakdown the surface of flax fibers allowing that same heat to then mildly scorch the cell-

ulose of the cloth. Where the body touches the cold limestone of the bench, the body is cooled and the image process is either retarded or stopped, while those areas of the body not in contact with the bench continue to radiate heat and thus produce image.

We can even speculate as to the reason the face cloth or chin band did not appear around the face of the image. The hair and beard,(28) along with the body, radiated heat, but the cloth tied later around the head under the chin did not take on enough heat from the body to transfer an image onto the Shroud, but the chin band may have contained some image, accounting for the dropping-out around the face.

John Heller and Alan Adler stated that image, as viewed on the Mylar tapes, does not exist under the blood.(29) If image has been produced by a natural mechanism, then from the statement that no image is under the blood, we must conclude that all blood was transferred immediately after the body was removed from the cross, before the shrouded body was brought into the tomb environment. If, however, not all the blood was transferred during initial contact with the Shroud, but was slowly moistened after clotting or drying, and transferred slowly, with a natural mechanism for image production, then I maintain that areas of image under the blood are more than possible, but probable. We must be cognizant of the ramifications which statements about blood/image sequencing incur. Image under the blood demands a fully natural mechanism for the formation of that image. Ultra violet fluorescence has not been conclusive in this respect either.(30) Figure 8 is a remarkable photo showing red "blood" particles on top of the fiber with a misty yellow of the image underneath. If, in this case, the yellowing is serum under the blood and not image, it must be noted that the misty yellow is not present in all fibers containing red particles. Blood and serum will not penetrate flax fibers.

The limestone of rock-cut tombs in Palestine-Transjordan is always moist, but especially so during the rainy season of the year, which for our purposes includes Passover/Easter. The bench or ledge (Figure 31) which held the body for final preparation would have saturated the cloth of the back of the shrouded body immediately, thereby moistening the clotted or dried blood and transferring the blood to the cloth faster than the front. In this case, there could

be a blood-image sequence. The slower saturation of the cloth of the front of the shrouded body, by way of air moisture, delayed the moistening rate of clotted blood and transfer of blood, allowing the image to form first. The sequence being image-blood. In both cases, a certain amount of non-clotted blood from larger wounds to the body would have permeated the cloth on initial contact and even penetrated to other side, ruling out image formation in that area. In this case, blood can be seen as an image inhibiting factor by providing a moist blockage of body contact with the cloth, but, in no terms, could it be considered image eradicating.(31)

Disturbances in blood coagulation which prolonged clotting time or stopped clotting entirely(32) could have resulted in a transference of non-coagulated blood which after drying liquefies immediately on contact with moisture,(33) as is present in the tomb.

It was also found that a body radiating heat in a cold atmosphere will produce vapor and no matter how slight, this may be an important factor, despite the claims that vapor would penetrate beyond the number of fibers which contain image.(34)

It was this theory for a natural image process we attempted to duplicate, first in local testing, then under the more controlled environment of a limestone tomb in Jerusalem.

THE FIRST IMAGE TESTS The first image tests I conducted used a small, hollow, three foot tall medical manikin on loan from Simulaids, Inc. of Woodstock, New York, the company which was to build the full scale manikin we would take to Jerusalem.

On August 14, 1985 the small manikin (nicknamed "Junior" to be easily distinguishable in test records from the large manikin), was filled with water to a temperature between 110° and 115°F to duplicate body heat. Blood was added and a colorless solution of "sweat" composed of normal salin (.9%) and acetic acid, to reproduce an acidic condition of both blood and perspiration in trauma and death. It was noted that the blood coagulated and fully dried within seconds after contact with the heat of the manikin. The prepared "body" was then wrapped in pure, untreated linen obtained from Belgium (Strathmore Natural #1290, Hamilton Adams, New York) which had been lightly dusted with calcium carbonate. The acetic acid and calcium carbonate set-up conditions for an acid-alkaline reaction which would be com-

pounded by heat. The shrouded body was placed in a totally dark basement room which had a temperature ranging between 62° and 65°F and a relative humidity from 58% to 66%. A water mist was sprayed first on a plastic sheet containing the powdered calcium carbonate, to replicate the dampness of the limestone tomb, then after placement of the manikin, it too was sprayed with the mist and was then left for a period of 30½ hours, Figure 33.

Upon examination of the cloth, image was obtained in the areas of the manikin's body which retained heat the longest, namely the chest and back, Figures 34 and 35. Image was inhibited, due to rapid cooling in the arms and legs, which have a much smaller relative area than those of an adult male. Image was also not obtained from the head, because of structural supports which did not allow the even heating of that area. Clotted, dried blood transferred poorly, when it transferred at all. Only the area treated with unclotted blood penetrated the cloth. This gives further support to a necessity for disturbance in blood which prolongs clotting time or stops clotting entirely.

One factor which was totally unexpected was the way both image and blood penetrated the cloth. The blood crusted on the outside of the cloth in a clearer manner than on the side next to the body. Furthermore, the image was also darker and more clearly defined on the outside of the cloth. Upon microscopical examination of fibers taken from the middle of the dorsal image area, it was observed that not all the fibers of the thread had the misty yellowing of image, but a good number of them were colorless, indicating an uneven penetration.

This test cloth was then sent to Dr. Alan Adler for his analysis which was summarized in a letter by him dated June 30, 1986:

> The images are very faint, however, they may become more distinct with time as more oxidation ensues. Like the material I studied from the Shroud of Turin, both image and non-image fibrils give positive tests for Fe, Ca, aldehyde, and cellulose carboxyl groups (upon spot tests).
>
> However, the differences are more striking than the similarities. The oxidation tests (aldehyde and carboxyl) are not as markedly different between image and non-image as with the Shroud samples. On the other hand the Ca tests are very markedly different between image and non-image, unlike Shroud samples. Further, the image here does fluoresce under UV, while the Shroud image does not.

A second image test was performed under the following conditions:

January 18, 1986.
Room temperature range: 48° to 50°F.
Relative humidity: 56% to 63%.
Sweat solution: normal salin (.9%), acetic acid, ammonia.
The water used to fill the manikin was heated to approximately 115°F. Powdered calcium carbonate was sprinkled on a plastic sheet where the manikin was to be placed. A heavy white Irish linen was then placed on the calcium covered plastic and was dusted with powdered myrrh and aloes. After the manikin was filled with the heated water, blood was applied, then the sweat solution was sprayed over the entire surface of the manikin. After wrapping the manikin securely in the linen, it was left for a period of 12 hours.

Image was again obtained in the areas affected in Test 1. The myrrh and aloes along with blood stains so confused the image areas that it was necessary to use a microscope to determine image fibers from those which had been coated by the different substances.

Six other image tests were performed between January 19 and January 23, 1986. All varied in the type of linens used with regard to the processing of the flax. Humidity, sweat solution, blood, and the use of myrrh and aloes were tried in different combinations. No further images were obtained, which led to the following conclusions: body heat alone, or simply the acidic fluids, or calcium carbonate by itself, or even two of the substances in combination are not sufficient to produce the reaction required to change the cellulose of the fiber. Linen which is highly processed will also not respond to the conditions due to the change already caused by the bleaching of the fibers. Vapor was frequently noticed rising from the enshrouded manikin during the test.

THE JERUSALEM TESTING The Introduction states the reasons for the choice of the tomb complex at the École Biblique.(35) While the primary testing concerned image formation, a number of other tests were also performed, each of which will be discussed in turn.

Figure 30 illustrates the plan of the tomb and the stations at which tests were conducted or daily records kept. Great care was taken to prevent any action or substance from affecting the environment of any of the test chambers. Chamber 2 was used for image experiments, Chamber 3 was used for tests by Rex Morgan, and Chambers 4-5 were kept as a control throughout except for three experiments in moisture saturation, contamination, and the effects of limestone

Legend for Figure 30:

1 - Burial chamber 1.

2 - Burial chamber 2, used for image tests.

3 - Burial chamber 3, used by Rex Morgan for tests.

4 - Burial chamber 4, used as a control area and for non-image tests.

5 - Burial chamber 5, used as a control area for temperature and humidity.

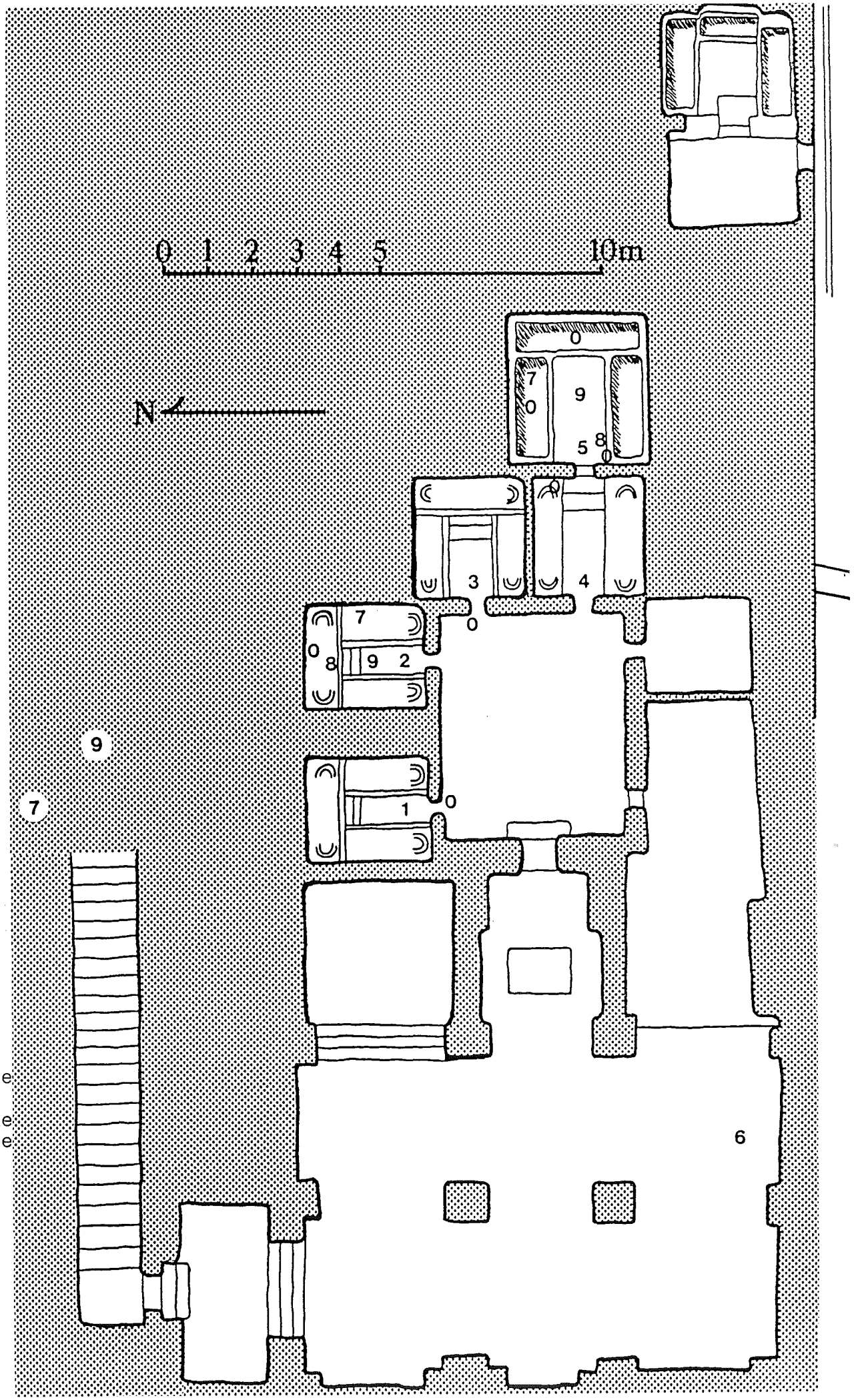
6 - Area used to prepare manikin before each image test.

7 - Areas where thermometers were placed to record temperature.

8 - Areas where long-stem thermometers were placed into pre-existing cracks in the benches to record limestone temperature.

9 - Areas where relative humidity was recorded.

0 - Areas where the moisture content of the limestone was recorded.



igure 30, The
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omb complex.

on blood-soaked linen. Figure 36 shows the full-scale manikin in place, ready to be filled with heated water for an image test. The area marked as #6 in Figure 30 is the modern mausoleum of the tomb complex. Water was heated outside the tomb (near #9), but the manikin was filled inside the tomb well away from Test Cahmber 2, so that both temperature and humidity in the test area would not be affected. The joints of the manikin were somewhat fragile, especially when the weight of the water-fill pulled against them, so movement of the manikin was kept to a minimum.

THE IMAGE TESTS Four image tests were performed instead of an original five which had been planned. This was due to a set-back in schedule when Customs held our equipment longer than expected. Five types of linen were chosen: Strathmore Flax from Belgium, dark and totally unprocessed; Strathmore Natural from Belgium, lighter than the previous type, but still having a minimum of processing, this was the kind of linen on which our first image was produced; Flaxweed 84-Dark from Ireland, a linen whose degree of processing falls between Strathmore Flax and Strathmore Natural, and is woven in a herringbone pattern; Flaxweed 84-Light from Belgium, an oyster colored, slightly processed linen woven in a herringbone pattern (which can be seen in Figure 56); "Irish White" unnamed by the distributor, from Ireland, a processed linen which has not been highly bleached being an oyster color, it was the type of cloth that produced our second image with Junior.

Each image test followed the same general pattern of first treating the manikin with a sweat solution which was allowed to dry, then filling the manikin with heated water, tying the wrists and ankles in the manner portrayed on the Shroud of Turin, taking the surface temperature, then carrying the manikin on a stretcher into the Test Chamber where the linen had already been spread on the bench. A final mist of the sweat solution was sprayed on the manikin before it was wrapped in the linen. Once in the linen, the cloth was secured with cotton rope around the neck, waist, and the ankles to keep the cloth next to the body. The temperature of the chamber and bench were recorded, as well as the relative humidity. Variables included the use of blood, myrrh, and aloes in the sweat solution and the "Filas Test."

It was the premise of the late Father Francis L. Filas, SJ that a coin which had been struck during the procuratorship of Pontius Pilate (AD 26-36) can be seen covering the right eye (if viewing the "positive" actually photo negative, white on black) of the face on the Shroud. The "Filas Test" consisted in the placement of a bronze coin on one eye of the manikin to examine the possibilities and characteristics of image transfer. Only one eye was covered so that the other could be used as a control for comparative purposes. The choice of the eye was alternated through the tests in case any structural variations exist in the manikin which might interfere with heat conduction.

The base of the sweat solution was Ringers Injection, a fluid used for the replacement of electrolytes in medical patients. Each 100ml of Ringers contains:

0.86g Sodium Chloride
0.030g Potassium Chloride
0.033g Calcium Chloride

147	Na^+ (Sodium)	concentration of electrolytes mEq/liter
4	K^+ (Potassium)	
4	Ca^{++} (Calcium)	
155	Cl^- (Chloride)	

Because Ringers represents somewhat normal fluid values, those chemicals which are expended by the body in high amounts in violent death were added to bring the fluid pH to 6.60 which is the average pH value of the body at the height of rigor mortis. The chemicals added included:

Lactic acid
Ammonia
Acetic acid
Urea
Magnesium
Potassium

Since myrrh and aloes are mild acids, they were added to the solution after the pH 6.60 was reached. When blood was added to the mixture, an anti-coagulant was also used for two reasons: If Christ suffered from heatstroke or a high body temperature, the coagulation system of the blood would have been disturbed, and if the blood coagulated in the solution an even distibution over the manikin would not have been achieved.

At the beginning and end of each image test, all staff and observers who were present, signed the records book as witnesses to

to the procedure. The image tests were as follows:

IMAGE TEST 1

Date: April 10, Thursday.
Beginning time: 6:28pm.
Test Chamber temperature: 60°F.
Bench temperature: 57°F.
Body temperature: 115°F (surface).
Relative humidity: 85%.
Linen used: Irish white.
Coin: placed on right eye.
Sweat Solution: The solution was brought to a pH of 6.60, then myrrh was added which brought the final pH to 5.73. Blood and aloes were not used, because of their dark color which confuses the detection of any image which might be obtained.

Date: April 11, Friday.
Ending time: 10:15pm.
Test Chamber temperature: 60°F.
Bench temperature: 59°F.
Body temperature: surface cold to the touch.
Relative humidity: 95%.
Observations: Some minor patches of darkening occurred on the cloth, but mostly staining from the myrrh. However, there was a pooling of the solution on the dorsal side at the small of the back, similar to that on the Shroud of Turin.

IMAGE TEST 2

Date: April 12, Saturday.
Beginning time: 5:27pm.
Test Chamber temperature: 61°F.
Bench temperature: 59°F.
Body temperature: 114°F (surface).
Relative humidity: 84%.
Linen used: Strathmore Natural.
Coin: placed on left eye.
Sweat solution: Myrrh, aloes, and blood were added to the solution.
Observations: In the outer-chamber, vapor was noticed rising from the manikin before it was carried into the Test Chamber. Once in the Test Chamber, a very slight amount of vapor was visible rising through the linen.

Date: April 13, Sunday.
Ending time: 6:10pm.
Test Chamber temperature: 61°F.
Bench temperature: 59°F.
Body temperature: cold to the touch.
Relative humidity: 75%.
Observations: Water staining and only small patches of darkened areas are observable on the cloth. The blood did not transfer well, but is bearly visible.

IMAGE TEST 3

Date: April 14, Monday.
Beginning time: 12:10pm.
Test Chamber temperature: 61°F.
Bench temperature: 58°F.

Body temperature: 116°F (surface).
Relative humidity: 80%.
Linen used: Flaxweed 84-Light.
Coin: not used.
Sweat Solution: Myrrh and blood were used, but no aloes.
Observations: Because air-pockets along the frontal surface of the manikin could not be eliminated, which disturbed the conduction of heat to the cloth, the manikin was positioned face down and the wrists were not tied, while the ankles were. No coin was used. Vapor was visible rising through the cloth.

Date: April 15, Tuesday.
Ending time: 6:35pm.
Test Chamber temperature: 61°F.
Bench temperature: 59°F.
Body temperature: cold.
Relative humidity: 84%.
Observations: Water stains and small patches of darkened areas. Hardly any blood transferred.

IMAGE TEST 4

Date: April 18, Friday.
Beginning time: 1:50pm.
Test Chamber Temperature: 62°F.
Bench temperature: 59°F.
Body temperature: 117°F (surface).
Relative humidity: 75%, brought up to 80%.
Linen used: Flaxweed 84-Light.
Coin: right eye.
Sweat Solution: The basic solution was brought to a pH of 6.63, then blood, myrrh, and aloes were added bringing the final pH to 5.70.
Observations: The manikin sprang a leak in the forehead filling port, which dictated that the body be positioned again on its back, this also made the use of the coin possible. While the ankles were tied, the wrists were not. Vapor was noticed rising from the linen. Because of the low relative humidity, a pure water mist was sprayed into the chamber, bringing the humidity up to 80%.

Date: April 19, Saturday.
Ending time: 5:15pm.
Test Chamber temperature: 61°F.
Bench temperature: 59°F.
Body temperature: cold.
Relative humidity: 75%.
Observations: A definite form was observed on the dorsal side of the cloth. There is a contrast between blood areas with patches of "image". A darkened area over the location of the coin was visible and was marked with black felt pen for ease of identification later.

EVALUATION OF IMAGE TEST 4 By far the most successful of all the image tests, including those with Junior, Test 4 produced a full dorsal image, Figures 37 to 43. There were some image patches on the frontal side, Figure 38, but it is difficult to visualize as a body

form. Flaxweed 84-Light was used a second time, because the two remaining types of linen, Flaxweed 84-Dark and Strathmore Flax, each have a husk-like outer layer on the fiber, unlike the fibers on the Shroud of Turin, which interferes with the identification of image. We did not leave the manikin in the Test Chamber for the length of time Christ's body was in the tomb, because all indications pointed to the image process being dependent on the heat of the body, so that once the body is cold, the image process is no longer active.

Absolute identification of image came after the testing was concluded and a microscope could be used. Some fibers showed an encrustation, Figure 46, similar to Shroud encrusted fibers, Figures 44 and 45. While images have only been obtained, during our testing, with the use of blood, blood is not part of the image, since other tests using blood often did not yield image. Test Cloth 4 fibers also exhibited a corrosive process on the surface, Figures 47 and 48. And, most striking of all, a misty yellow coloration was obtained in otherwise colorless fibers. Figures 49 and 51 show this coloration. Image is best detected at a magnification of 100x with an overexposure of light as in Figures 50 and 52. These photos illustrate a coloration change within the fiber and not a coating as caused by myrrh, aloes, or blood seen in Figure 46.

The Filas Test was more successful than anticipated, Figures 55 and 56. While an actual detailed image was not produced, fibers do exhibit image qualities, Figures 57 to 60. The darkening of the fiber showed a different coloration than that of body image; a green-gray rather than the misty yellow. This is due, no doubt, to the oxidation of the bronze coin (Figure 54) through age. A metallic residue was also detected in the fibers. The fact that detail from the coin was not transferred to the cloth may have been caused by the leak in the manikin's forehead which flooded the face. Figure 55 shows the marked area of the coin, the tip of the nose, and the flow pattern of the water down each side of the face from the nose. The chin area is also distinguishable.

Figure 37 shows the dorsal image in the negative and Figure 39 in the positive, photographically speaking, although Figure 37 is more of a "positive" image visually. Ultra violet light did much to enhance the image in Figures 41 to 43.

Another interesting result was the transference of the side of the leg and foot, especially visible (at the right) in Figures 40 and 43. This illustrates that a contact process is definitely at work. Dr. Gilbert and Bonnie Lavoie along with Reverend Vincent Donovan and John Ballas,(36) drew the conclusion that the image mechanism, as viewed on the Shroud of Turin, is not a contact process. They stated that an off-image blood mark at the left elbow on the Shroud, while the cloth was in intimate contact with the right forearm where image is seen, had equally intimate contact with the back of the right upper arm where no image is seen, thus ruling-out a contact theory. On the contrary, the back of the arm was in contact with the cold from the limestone bench. The arm has a smaller surface area than other parts of the body and would cool more rapidly, which inhibited image formation. Why, in the case of Test Cloth 4, did the side of the leg and foot transfer when other areas of the body, which were equally wrapped, not touching the bench, did not produce image? At present, this is unexplainable.

In regard to our testing, I made one grave error (no pun intended!) Since Jerusalem was experiencing near drought conditions,(37) the tombs were drier that I had ever seen them before. The limestone would actually fall in powdered form from the ceiling as we worked in the chambers. I had always noticed a water seepage in my previous work. The humidity in Test Chamber 2 had been 85%, 84%, and 80% for the first three tests respectively. By the fourth image test, the humidity had dropped to 75%. Out of desperation to make the tomb conform to my previous experience for the last test, I raised the humidity to 80% by a water mist sprayed into the chamber. Instead, I believe that if I had allowed the humidity to remain at 75%, or drop even further, a better image would have been obtained. I say this for three reasons: First, the two early tests conducted with Junior, which produced images showed humidity to be 58%-66% and 56%-63% respectively. Secondly, in the remaining six tests with Junior, the linen was saturated to "simulate" the dampness of the tomb, but no images were produced. Thirdly, the limestone of the bench which came in contact with the dorsal side of the body was drier than the air in the test chamber which had been affected by the mist. I believe that the relative humidity for image formation must be below 80%, but I am unable

to recommend an optimum range. It should be noted that in later moisture saturation tests, linen types which absorbed moisture more slowly are those on which image was produced.

Analysis of the image on the VP-8 has not yet been attempted, but I would caution any conclusions based on its results, because the dorsal image on the Shroud of Turin is not comperable to the frontal image, and in light of the technical difficulties encountered in Jerusalem, Test Cloth 4 would not be expected to yield much.

The fact that our test images have always penetrated the cloth has been an area of criticism from other researchers.(38) In Jerusalem Test Cloth 4, the image also penetrated, but not in all areas. The area of the side of the leg and foot, while distinct on the dorsal inside of the cloth, is visible as only a series of random spots, each no more than several millimeters to a centimeter in diameter. The manner in which the threads have been affected is the same as image cloths from Junior's tests. When the thread is separated into its fibers under the microscope, only some of the fibers, those of the two surface sides, have image coloration, while the center fibers are colorless.

While the analysis of Junior's first image test was only partially favorable, I have every reason to suspect that future analysis of our Jerusalem Test Cloth 4 will exhibit a great similarity to the Shroud. A sweat solution which more closely matches body chemistry was used. Myrrh and aloes had been missing in the first experiment. A genuine limestone tomb provided the correct environment with a higher alkalinity. And it must not be forgotten, the possible age of the Shroud and the cathedral fire of 1532 can greatly alter chemical and especially organic substances. Any test shroud must be considered in the light of these two factors.

ADDITIONAL TESTS Since an accurate environmental survey of a Palestinian rock-cut tomb had never been conducted, temperature in the interior and exterior of the tomb was recorded, as well as relative humidity (by sling psychrometer), temperature of the limestone benches and moisture content of the limestone (by use of the Delmhorst JC-1 Moisture Monitor). Figure 30 gives the locations of all the stations involved. The values for temperature and humidity are listed on page 47, while moisture is on page 48.

Two tests dealt with moisture saturation rates for linen. one set of the five types of linen were suspended in the air by a metal rack, while a second set was placed on the limestone bench, also for the purpose of detecting the types of contaminants which might be picked-up from exposure to a bench. The saturation rates for both of these tests are listed on page 49.

Another contamination test involved blood-soaked linen which was placed on the limestone bench. The purpose, along with the study of acquired contaminants, is to determine the effect, if any, the limestone might have on blood. Analysis of this test is still in process.

The limestone sampling which was performed in Jerusalem and at different sites around the country is discussed in detail in Chapter 3. Pollen sampling was requested by Paul Maloney, Projects Director of ASSIST, and those samples have been given to him.

DATE:	TIME:	TEMPERATURE			HUMIDITY			BENCH TEMPERATURE	
April		Exterior/Control/Test Chamber			Exterior/Control/Test Chamber			Control/Test Chamber	
10-Thursday	3:00pm	70°F	58°F	60°F	57%	95%	85%	55°F	57°F
	6:45pm	60°F	59°F	60°F	70%	100%	85%	56°F	57°F
11-Friday	7:00am	60°F	58°F	test-1	61%	100%	test-1	56°F	test-1
	10:35pm	(87°high)	58°F	60°F	--	100%	95%	56°F	59°F
12-Saturday	2:00pm	83°F	60°F	61°F	44%	89%	89%	55°F	59°F
	5:55pm	--	--	61°F	--	--	84%	--	59°F
13-Sunday	8:10am	74°F	59°F	test-2	31%	95%	test-2	55°F	test-2
	1:00pm	85°F	59°F	test-2	26%	95%	test-2	55°F	test-2
	7:00pm	72°F	57°F	61°F	40%	84%	75%	56°F	59°F
14-Monday	7:10am	69°F	58°F	61°F	43%	95%	84%	55°F	59°F
	12:10pm	74°F	58°F	61°F	44%	89%	80%	55°F	58°F
15-Tuesday	7:00am	57°F	58°F	test-3	100%	89%	test-3	56°F	test-3
	6:30pm	--	--	61°F	--	--	84%	--	59°F
16-Wednesday------		--	--	--	--	--	--	--	--
17-Thursday	6:00pm	71°F	58°F	61°F	39%	95%	80%	55°F	59°F
18-Friday	1:50pm	84°F	58°F	62°F	30%	89%	75%/80%	55°F	59°F
19-Saturday	4:45pm	74°F	58°F	61°F	54%	100%	75%	55°F	59°F
20-Sunday	10:40am	81°F	58°F	61°F	28%	84%	84%	56°F	59°F

LIMESTONE MOISTURE CONTENT

DATE: April	TIME:	STATIONS: 1	2	3	4	5	6	7
10-Thursday	4:30pm	119.5%	128.7%	101.1%	89.6%	95.4%	110.3%	112.6%
11-Friday	7:20am	117.2%	test-1	94.2%	88.5%	91.9%	108.0%	114.9%
12-Saturday	2:40pm	106.8%	128.7%	97.7%	91.9%	103.4%	110.3%	94.2%
13-Sunday	8:15am	117.2%	test-2	96.5%	89.6%	94.2%	105.7%	112.6%
	1:00pm	117.2%	test-2	94.2%	89.6%	89.6%	103.4%	112.6%
	6:55pm	112.6%	126.4%	96.5%	89.6%	91.9%	98.8%	112.6%
14-Monday	7:20am	112.6%	124.1%	96.5%	89.6%	91.9%	103.4%	117.2%
	11:35am	112.6%	126.4%	98.8%	89.6%	89.6%	101.0%	117.2%
15-Tuesday	7:20am	108.0%	test-3	101.0%	91.9%	91.9%	103.4%	117.2%
16-Wednesday	--	--	--	--	--	--	--	--
17-Thursday	5:57pm	117.2%	121.8%	96.5%	89.6%	91.9%	98.8%	108.0%
18-Friday	12:45pm	117.2%	124.1%	97.7%	89.6%	89.6%	96.5%	108.0%
19-Saturday	4:50pm	108.0%	137.9%	100.0%	87.3%	91.9%	105.7%	128.7%

Figure 30 shows the stations where moisture readings were taken. They are marked as "0" on the plan. The exact designations are as follows:

Station 1 = at the entrance to chamber 1, right side of doorway.

Station 2 = at the rear of chamber 2, above the back bench.

Station 3 = at the entrance to chamber 3, in the upper part of the doorway.

Station 4 = in chamber 4, above the headrest of the left bench.

Station 5 = in chamber 5, at the right of the doorway.

Station 6 = in chamber 5, approximately 1m above the trough grave on the left side.

Station 7 = in chamber 5, approximately 1m above the trough grave at the rear of the chamber.

Please Note: the Delmhorst JC-1 Moisture Monitor, which was used for all the moisture tests, does not measure absolute, but rather, relative moisture saturation. Inorganic materials, like limestone, will give much higher than actual readings.

CLOTH SATURATION & CONTAMINATION TEST (Cloth placed on limestone bench)

DATE: April	TIME:	STRATHMORE FLAX	STRATHMORE NATURAL	FLAXWEED-84 DARK	FLAXWEED-84 LIGHT	IRISH WHITE
20-Sunday	10:00am	dry	dry	dry	dry	dry
	11:00am	85.5%	87.7%	85.5%	86.6%	84.4%
	1:00pm	86.6%	88.8%	88.8%	86.6%	86.6%
21-Monday	7:30am	88.8%	91.1%	88.8%	88.8%	88.8%
	12noon	88.8%	91.1%	88.8%	88.8%	88.8%

CLOTH SATURATION (The strips of linen were suspended from a metal rack, the strips being 5cm from the bench and 40.5cm from the wall)

20-Sunday	10:10am	dry	dry	dry	dry	dry
	11:10am	83.3%	84.4%	84.4%	84.4%	80.0%
	1:10pm	86.6%	95.5%	93.3%	87.7%	84.4%
21-Monday	7:30am	88.8%	91.1%	88.8%	88.8%	88.8%
	12noon	88.8%	91.1%	88.8%	88.8%	88.8%

Please Note: the Delmhorst JC-1 Moisture Monitor, which was used for all the moisture tests, does not measure absolute, but rather, relative moisture saturation.

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(3) Shibolet, et al, p. 542.

(4) Barbet, p.208. Another example of increased body temperature in a cool environment which closely parallels Barbet's account is that found in Zugibe, The Cross and the Shroud on p. 108, he describes the 70°F air-conditioned test room and yet, "A marked sweating reaction became manifest in most individuals, which encompassed the entire body and in some instances actually drenched the volunteers, running off the toes to form a puddle on the floor."

(5) Zugibe, Cross and Shroud, hematidrosis, p. 13; scourging, p. 19.

(6) Shibolet, et al, p. 539. One of the cases (#4) died 1½ hours after the onset of the illness.

(7) Zugibe, Cross and Shroud, pp. 89-90.

(8) Clarence G. Strub and L.G. Frederick, The Principles and Practice of Embalming (Dallas, Texas, 1967), p. 65.

(9) Strub & Frederick, Embalming, p. 91. For temperature of the body at death, see pp. 64, 73, 74, 77, 78, 92, 93, 94, 527.

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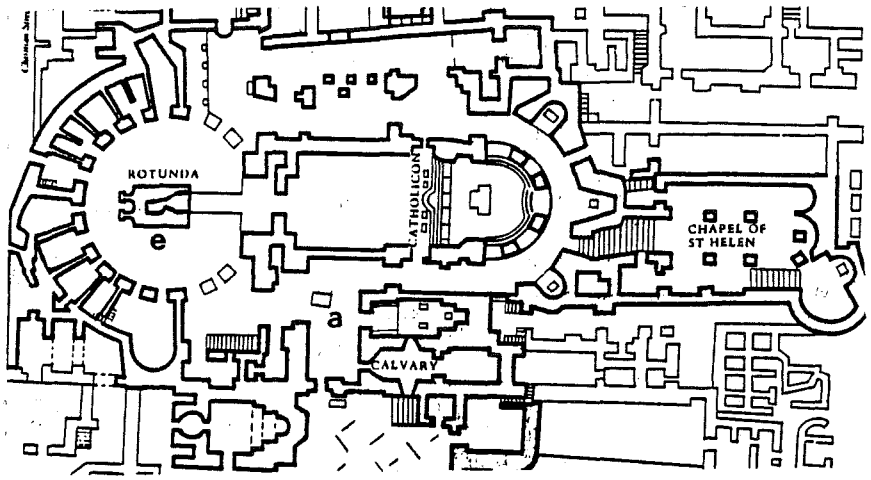
(13) Strub & Frederick, Embalming, pp. 64, 78, 79, 100-107. Camps et al, Gradwhol's, 83-85.

(14) Monsignor Giulio Ricci, The Way of the Cross in the Light of the Holy Shroud (Milwaukee, 1982), p. 79; Ricci, Guide to the Photographic Exhibit of the Holy Shroud (Milwaukee, 1982), p. 55.

(15) The "Stone of Anointing" is near the entrance to the Church of the Holy Sepulchre, between Calvary and the Edicule (e) and is marked as "a" on the plan of the Church:



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(23) L.A. Schwalbe and R.N. Rogers, "Physics and Chemistry of the Shroud of Turin: A Summary of the 1978 Investigation," Analytica Chimica Acta, Vol. 135 (1982), p. 14.

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(27) Dr. Sebastiano Rodante, "Il Sudore Di Sangue E Le Impronte Della Sindone," Sindon, No. 21 (April, 1975), pp. 6-11. For Dr. Judica Cordiglia, see Alfred O'Rahilly, The Crucified (Dublin, 1985), pp. 66-67.

(28) Barbet, p. 208, "The hair and beard were literally drenched."

(29) John Heller and Alan Adler, "A Chemical Investigation of the Shroud of Turin," Canadian Society of Forensic Science Journal, Vol. 14, No. 3 (1981), p. 91.

(30) Fluorescent margins are seen around the side wound, the wrist wound, and the blood flow at the right foot on the dorsal image, but not at other blood locations, such as the flow across the back and left foot region. Schwalbe & Rogers, p. 14. Robert H. Dinegar, "The 1978 Scientific Study of the Shroud of Turin," Shroud Spectrum International, No. 4 (September, 1982), pp. 6-11.

(31) Heller & Adler, p. 95. Tests show how difficult it is to remove image.

(32) Shibolet, et al, p. 545.

(33) Zugibe, Cross and Shroud, p. 151.

(34) Schwalbe & Rogers, pp. 29, 32.

(35) For an excellent description of this tomb see, Gabriel Barkay and Amos Kloner, "Jerusalem Tombs from the Days of the First Temple," BAR, Vol. XII, No. 2 (March/April, 1986), pp. 22-39, cave complex one.

(36) Lavoie, et al, Part I, pp. 14-19.

(37) See The Jerusalem Post, April 8, 1986 and In Jerusalem (The Jerusalem Post local supplement) April 11, 1986.

(38) Sister Damian of the Cross, OCD, The Loss of the Image: A Conservator's Report on the Shroud of Turin, July 1985 (Carmelite Monastery, Salt Lake City, Utah).

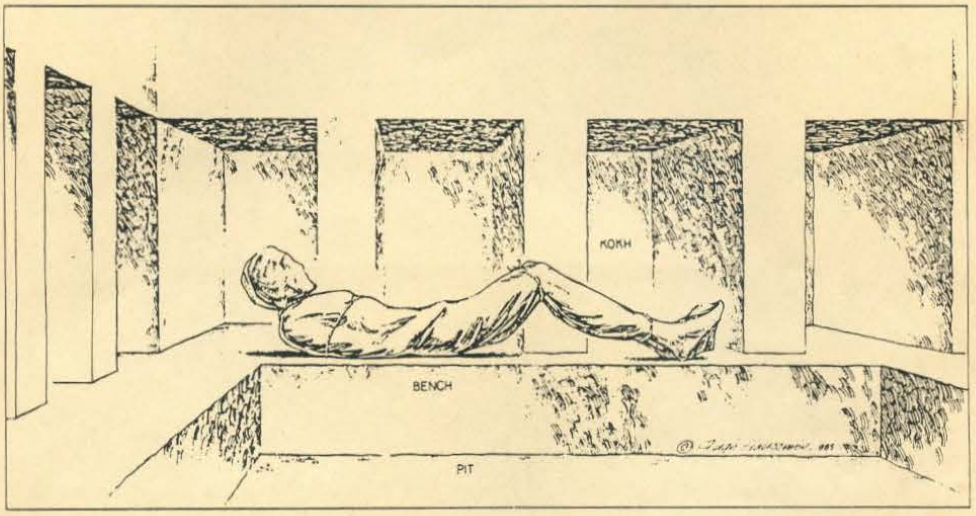

Figure 31

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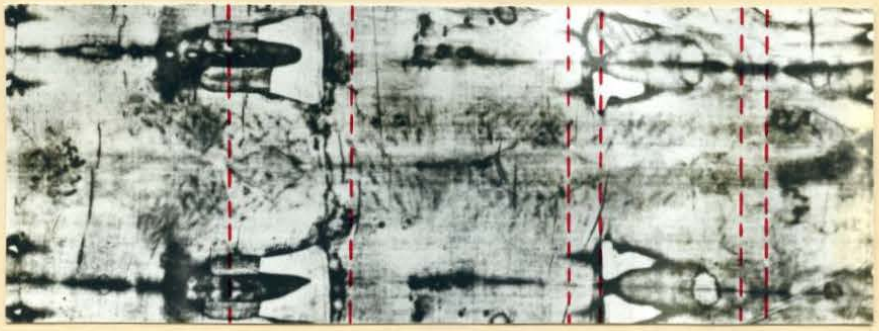


Figure 32, dorsal image of the Shroud of Turin.
Courtesy of the Holy Shroud Guild ©.

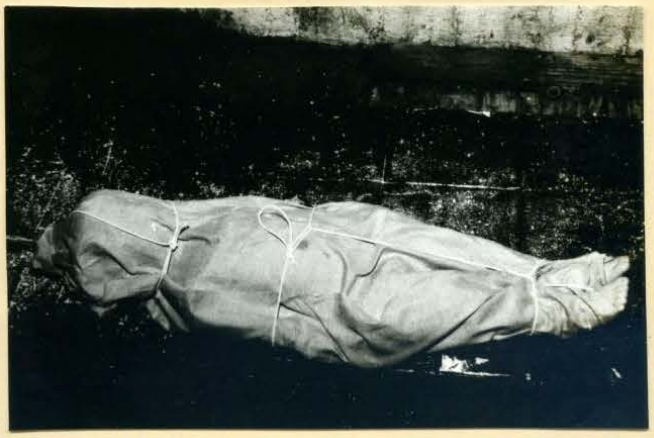


Figure 33, "Junior" at the end of the first image experiment. Photo by Damian.

Figure 34, First test cloth, frontal image, water stain, and blood. Photo by Damian.

Figure 35, First test cloth, dorsal image and calcium carbonate. Photo by Damian.

Figure 36, The manikin awaiting an image test.

Figure 37, Jerusalem Test Cloth 4, dorsal, negative image.

Figure 38, Test Cloth 4, frontal image.

Figure 39, Test Cloth 4, dorsal image.

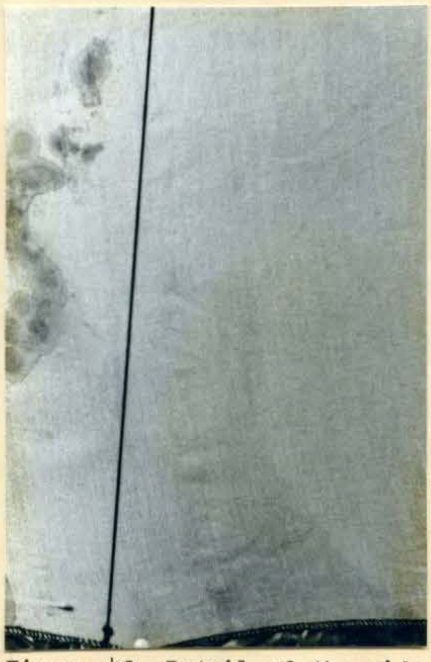


Figure 40, Detail of the side of the leg and foot.

Figure 41, Jerusalem Test Cloth 4, dorsal image photographed with ultra violet light with filter by Damian.

Figure 42, Jerusalem Test Cloth 4, dorsal image photographed with ultra violet light by Damian.

Figure 43, Detail of dorsal image lower leg area, showing especially the side of leg and foot at the right. Photo by Damian.

Figure 44, Shroud sample 1HB, encrusted fiber. Photograph taken at 100x by Damian.

Figure 45, Detail of encrusted fiber (1HB) taken at 400x by Damian.

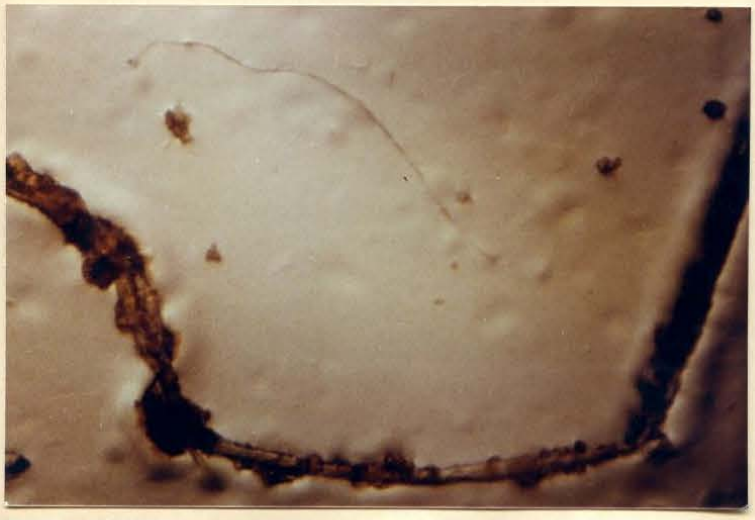


Figure 46, Fiber from Jerusalem Test Cloth 4 showing encrustation similar to Shroud fiber. Photographed at 100x by Damian.

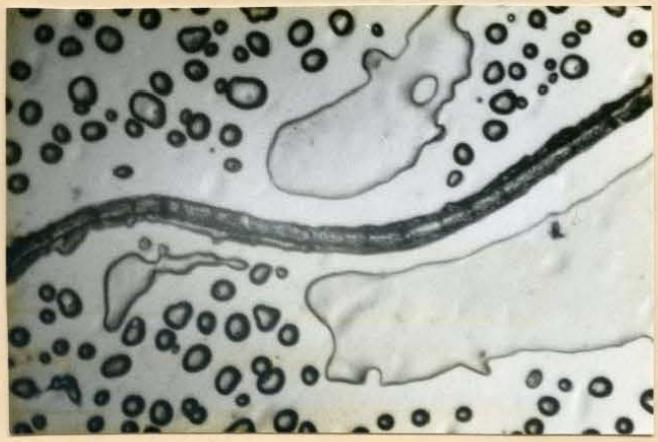


Figure 47, Jerusalem Test Cloth 4, corroded fiber from image area. Photographed at 100x by Damian.

Figure 48, Detail of corroded fiber. Photographed at 400x by Damian.

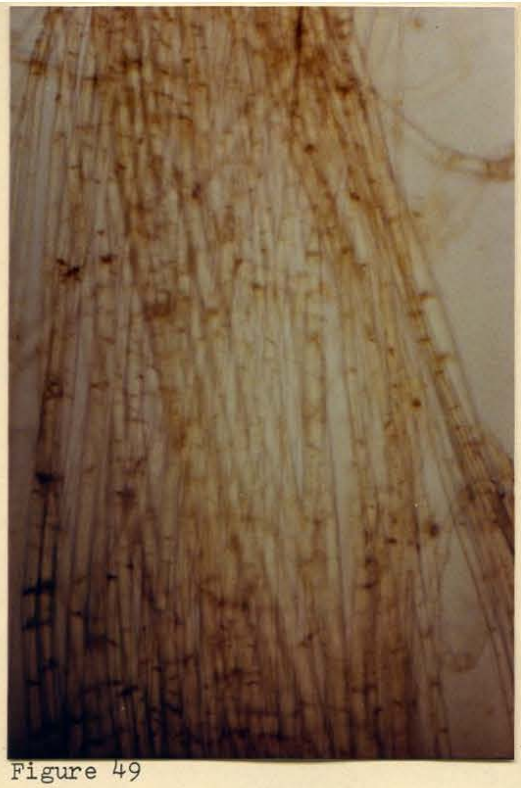


Figure 49

Figure 50

Figure 51

Figure 52

Photos by Damian

Figure 53, Pontius Pilate coin from the collection of Harold Nelson, Corpus Christi Holy Shroud Memorial.

Figure 54, Pontius Pilate coin from the collection of Rodger Apple, Albany Center Turin Shroud.

Figure 55, Jerusalem Test Cloth 4 face area, frontal image, with coin marked. The tip of the nose as well as chin are visible.

Figure 56, detail of the coin area.

Photos by Damian

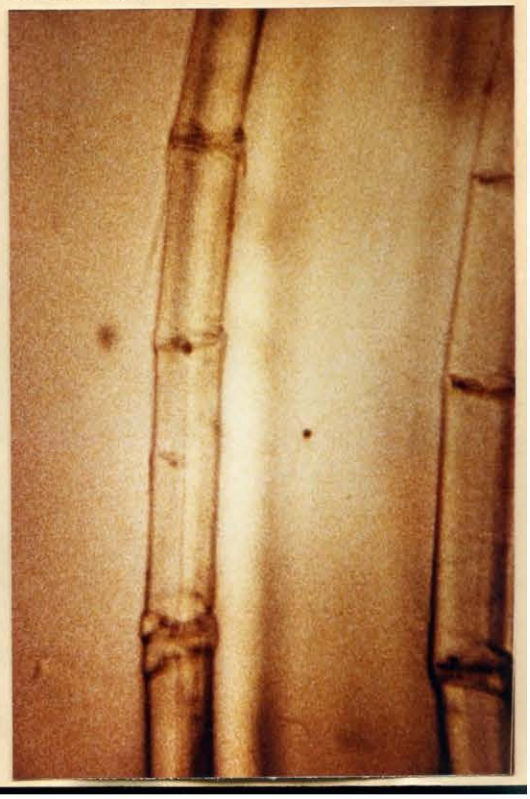
Figure 57.

Figure 58.

Figure 59.

Figure 60.

Photos by Damian



CHAPTER 3

LIMESTONE

If the Shroud of Turin is actually a burial cloth, there should be clues from tombs within an archaeological context which would either support or negate that possibility. In 1978, STURP subjected the Shroud to numerous scientific tests. Among those, Mylar tape samples were taken from areas on and around both the frontal and dorsal images, as well as vacuuming areas for loose particulates of matter.

From the tapes, vacuuming, and other tests, all foreign and original matter could be somewhat explained or accounted for except one: large quantities of calcium with small amounts of strontium and iron. Heller and Adler speculated from their tests that the presence of such a contaminant must be due to a khaki-like process[1] where cloth fibers soaked in pond water absorb the minerals contained in that water. Dr. Giovanni Riggi, who vacuumed "dusts" from the Shroud found that those compared most favorably to that which was taken from Egyptian mummies.[2]

Upon examination of the Mylar tapes, we became convinced that the source of the greater calcium contamination was, quite simply, a Palestinian rock-cut tomb.[3] The tombs of Palestine/TransJordan are carved out of limestone, or calcium, and while possibly 2000 years old, that limestone remains wet, pliable, and rubs off easily with the slightest contact. If an enshrouded body were placed in such a tomb, considerable calcium contamination would be unavoidable (see Figure 31). Even as the burial party entered the tomb, which, because of the small entrance admitted only one person at a time, limestone would have rubbed off onto the Shroud as the body was carried through the entrance.

Geologists can determine the origin of various types of marble by the contaminants found in it, giving characteristic colors and textures. Common examples would be Italy's fine white carara or Ireland's chunky, green conamara. Limestone is a geologically "younger" form of marble with contaminants traceable to geographical regions. Since the Shroud is thought to be the burial cloth of Christ, why not compare calcium samples from it with samples

from Jerusalem and especially from an area near the traditional site of Christ's tomb?

Samples from inside a tomb were obtained from Jerusalem. Kohlbeck made thin sections and subsequent microscopical analysis (Figures 63 and 65) of the samples showed the limestone to be aragonite and more specifically travertine. Aragonite is much less common than calcite, the more common crystalline form of limestone. Aragonite is formed under a much narrower range of conditions than calcite and will form from calcite solutions at 80° to 100°F. Formation of aragonite will also occur at lower temperatures when barium, strontium, iron, or lead are present. Aragonite can be found in many iron deposites particularly when the iron is present as siderite. The aragonite samples from the tomb were fairly pure and x-ray fluorescence showed only a small quantity of iron and strontium and no lead.

Observation of microscopical tape sample 1AB from the foot area of the dorsal image on the Shroud showed a few small particles of a crystalline material present in this sample, Figures 62 & 64. Little could be done microscopically in the environment of the Mylar tape used to lift the sample, because the tape had crystalline properties which interferred with obtaining optical information. Thus the risk was taken to recover these few crystals and remount them in a 1.680n_D Cargille immersion oil. The intermediate or β index of aragonite is 1.680 and a match at specific orientations would be a good indication of the possibility of aragonite. An interference figure at 1250x having a small 2V angle estimated at 18-20° optically negative was observed. In one orientation there was a match for the 1.680 index oil. These optical properties would be expected from aragonite and this is a strong suggestion that these fragments, particularly when compared with the Jerusalem samples, are aragonite. The aragonite samples were also found to be mildly alkaline, with a tan to brownish color, probably due to the presence of iron. The pH of the sample was estimated to be 8 to 8.5 based on the green color reaction with pH paper.

Further analysis was conducted by Dr. Ricardo Levi-Setti[4] of the Enrico Fermi Institute of the University of Chicago, who put both Shroud and Jerusalem samples through his high resolution scanning ion microprobe and produced graphs (Figures 66 & 67).

which were a match, except for the minute pieces of flax which could not be separated from the Shroud's calcium and caused a slight organic variation.

During ESSJ's April testing in Israel, nine sites were sampled (Figure 61), which included: (1) Emmaus; (2) Jericho, at Herod's Palace; (3) Qumran; (4) Beth Shan; (5) Sepphoris; (6) and (7) Beth She'arim; (8) Jerusalem, in the École Biblique tomb complex; and (9) Mt. Carmel.

Figures 68 to 74 show energy dispersive charts made from the electron microscope (except for Beth Shan which was a predominately volcanic area). Each chart shows a difference in limestone, but it must be noted that elements of less than 2% are not recorded and greater variation is present as shown by Levi-Setti's charts. The match between Jerusalem and Shroud samples is valid and I firmly believe that any other site tested would be different. The Shroud was indeed in Jerusalem at one time in its history.

Of the elements present in the various samples, it is important to note that potassium (K) is found in the sample from the École, which was taken from the bench of the tomb, on the Shroud, and in other types of burial wrappings.(5) This potassium must come from the presence of a human body, whether in the process of decomposition or, as in the case of the Shroud, from the severe sweating of the individual who had been wrapped in the cloth.(6) The presence of a human body in such a condition must certainly be considered as another piece of evidence for the authenticity of the Shroud as a genuine burial cloth.

The "even" or "uniform" distribution of calcium, reported by some scientists,(7) over the surface of the Shroud, could be attributed, possibly, to the folding and rolling of the cloth repeatedly which has caused a considerable distribution of loose particles of various types all over the Shroud. In my observation of the Mylar tapes, however, some exhibited much higher amounts of calcium than others, while still others had practically none. The foot area, sample 1AB, contained the highest concentration, the dorsal image area more than the frontal and so on, all of which illustrate the previous presence of a human body, one whose feet were dirty from the walk to his crucifixion and contact points relevant to position-

ing in burial.

There are two levels of calcium contamination on the Shroud. The uniform distribution attributed by Heller and Adler to the khaki or retting process is exactly that. Minute amounts of calcium absorbed during prolonged soaking in water. This type of contaminant is present on all types of linen, ancient and modern, but cannot be viewed microscopically even at very high powers, but must be found with the electron microscope or ion microprobe. However, a second level of calcium contamination, that from the tomb, is easily visible at 40x, more at 100x, and larger quantities at 400x, as seen in Figures 76 to 79. This second level of contamination is not visible on modern linen, but rather ancient types from tomb environments, such as those discussed by Giovanni Riggi,(8) Coptic samples viewed by me,(9) and other Egyptian sources.(10) That large particles of calcium can be observed on Egyptian mummies is no surprise, since the tombs in which those bodies were buried, the pyramids, the Valley of the Kings, etc., are also all limestone in construction.

Figure 75 shows modern linen fibers which have been treated with a paste of Jerusalem limestone made with distilled water. The slightly alkaline limestone attacked the outer skin of the fibers producing a color very similar to image fibers from the Shroud. The small amount of iron in the limestone is responsible for the yellow color. The iron can be transferred by a surface attack of weak alkali on the outer skin of the fiber by a process known as mercerization.

Please note: Figure 64 and 65 were photographed with a gypsum plate.

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(2) Giovanni Riggi, "The Dusts of the Holy Shroud of Turin," A progress report on the work of the Turin section of STURP, New London, Connecticut, October 9, 1981. Riggi, "Electronic Scanning Microscopy and Microanalysis of Dust Taken from Burial Fabrics of Egyptian Mummies, in Relation to Dust Taken from the Shroud of Turin," Turin, June 15, 1981. Riggi and P. Martinetto, "Biological Reactivation Tests on Holy Shroud Dusts," Turin, June 30, 1981.

(3) Joseph A. Kohlbeck and Eugenia L. Nitowski, "New Evidence May Explain Image on Shroud of Turin," BAR, Vol. XII, No. 4 (July/August, 1986), pp. 23-24.

(4) R. Levi-Setti, G. Crow, and Y.L. Wang, "Progress in High Resolution Scanning Ion Microanalysis," Scanning Electron Microscopy, II (1985), pp. 535-552.

(5) Percy E. Spielmann, "To What Extent Did the Ancient Egyptians Employ Bitumen for Embalming?" The Journal of Egyptian Archaeology, Vol. XVIII (1932), pp. 177-180. Rosalie David, ed., Mysteries of the Mummies (London, 1978).

(6) E.M. Iyer, M.B. Dikshit, D.K. Banerjee, and S. Suryanarayana, "100% Oxygen Breathing During Acute Heat Stress: Effect on Sweat Composition," Aviation, Space, and Environmental Medicine, Vol. 54, No. 3 (1983), pp. 232-234.

(7) L.A. Schwalbe and R.N. Rogers, "Physics and Chemistry of the Shroud of Turin: A Summary of the 1978 Investigation," Analytica Chimica Acta, Vol. 135 (1982), p. 17.

(8) See again reference (2).

(9) Coptic funerary linen from Egypt, currently in the textile collection of the Philadelphia College of Textiles and Science, the Paley Design Center in Philadelphia, Pennsylvania. Registration #1974.52.5.

(10) See again reference (5).

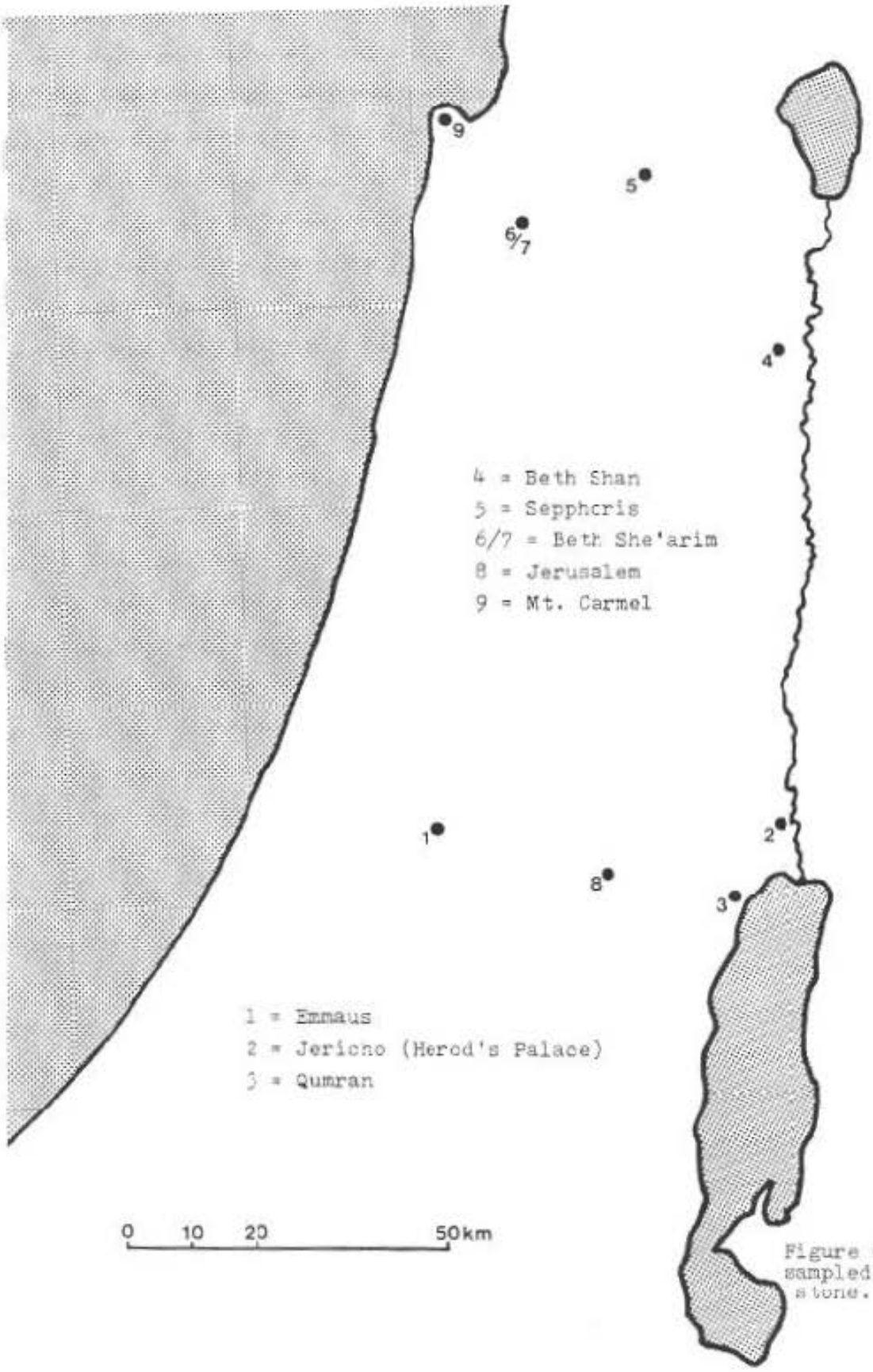


Figure 61. Sites sampled for limestone.

Figure 62

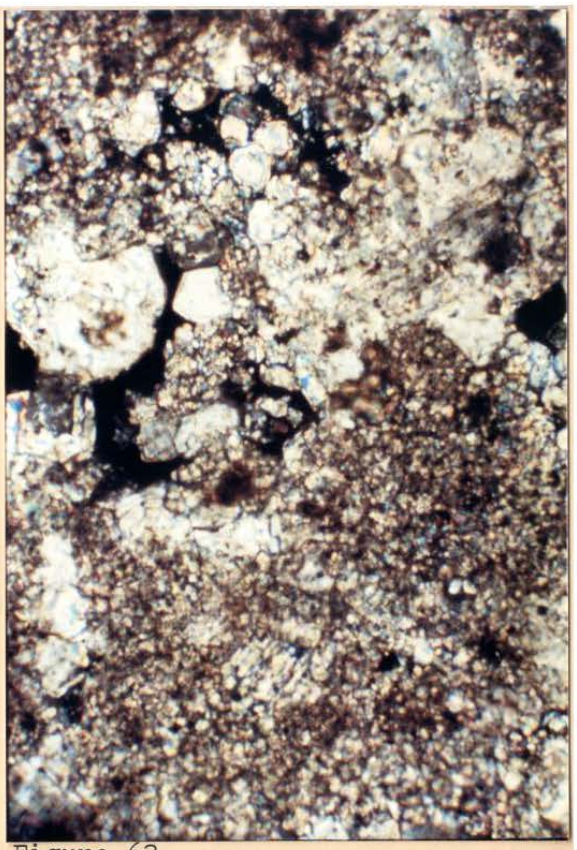


Figure 63

Photos by Kohlbeck

Figure 64

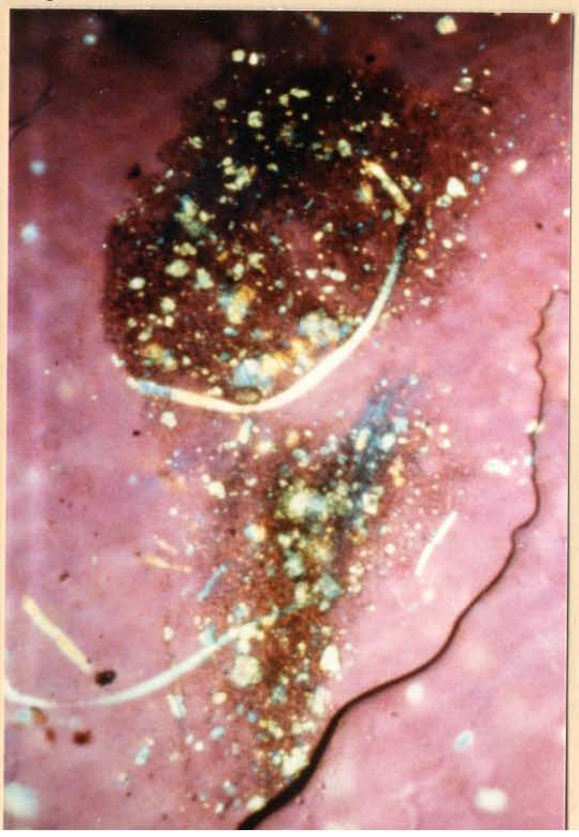
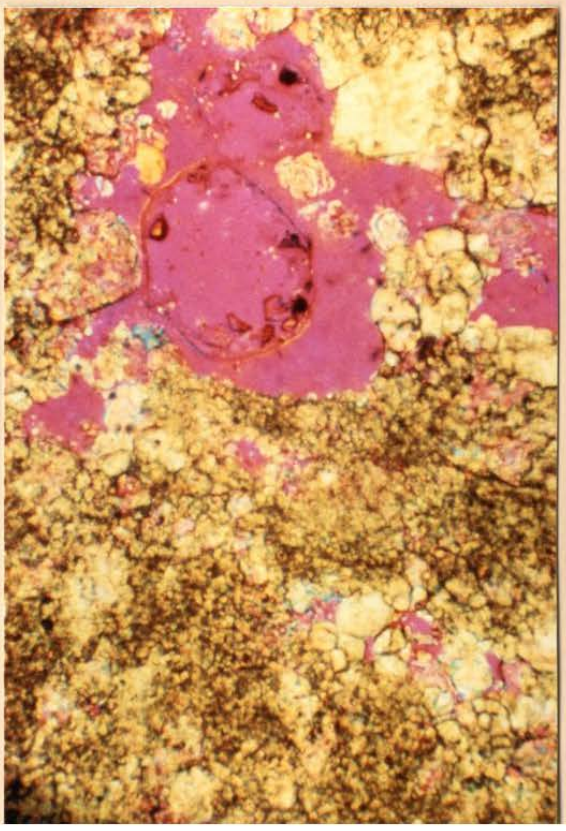
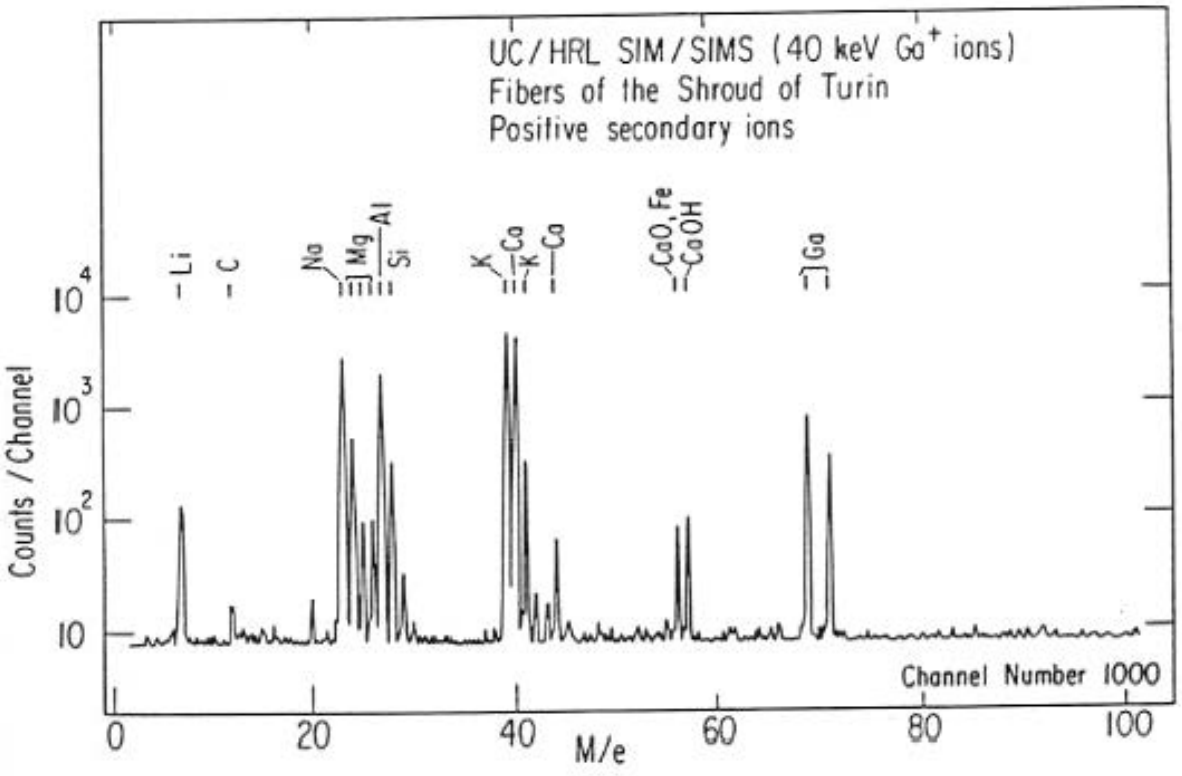


Figure 65




UC / HRL SIM / SIMS (40 keV Ga+ ions)
Fibers of the Shroud of Turin
Positive secondary ions
Li
C
Na
Mg
Al
Si
K
Ca
K
Ca
CaO, Fe
CaOH
Ga
Counts / Channel
10^4
10^3
10^2
10
Channel Number 1000
0
20
40
60
80
100
M/e

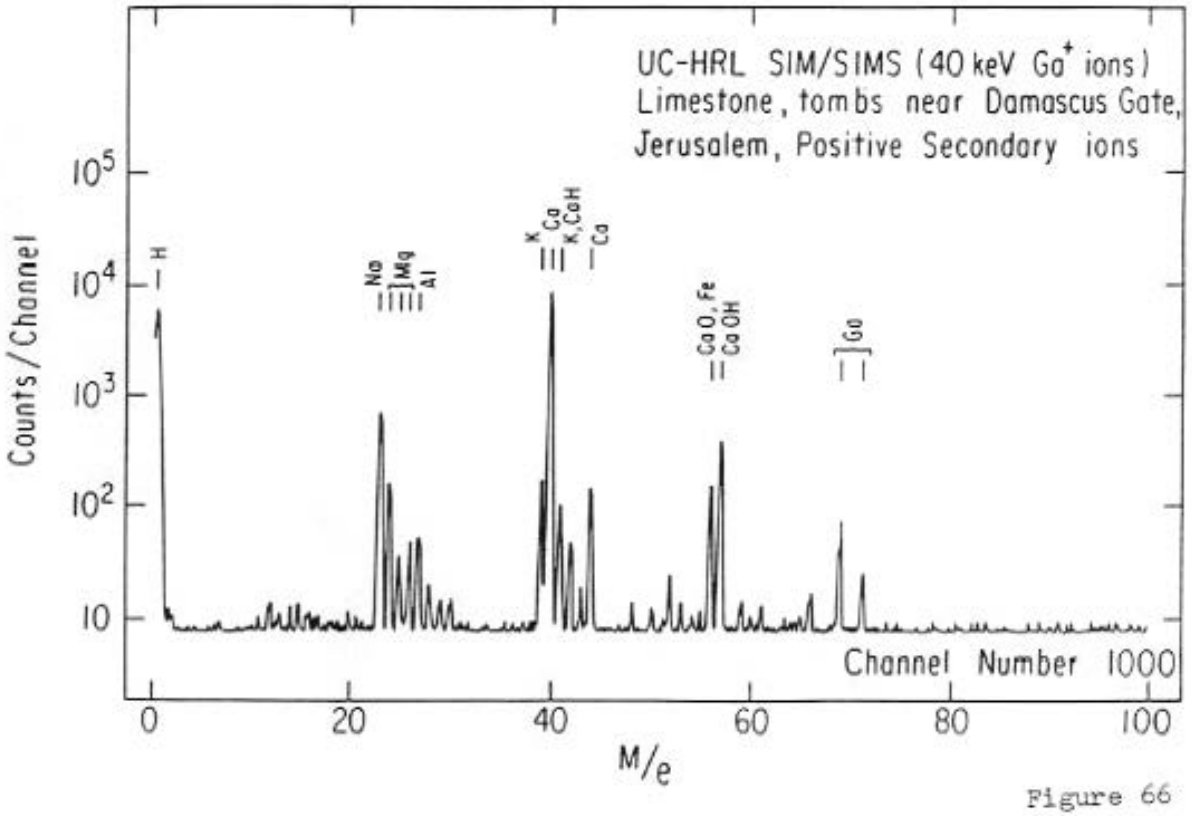
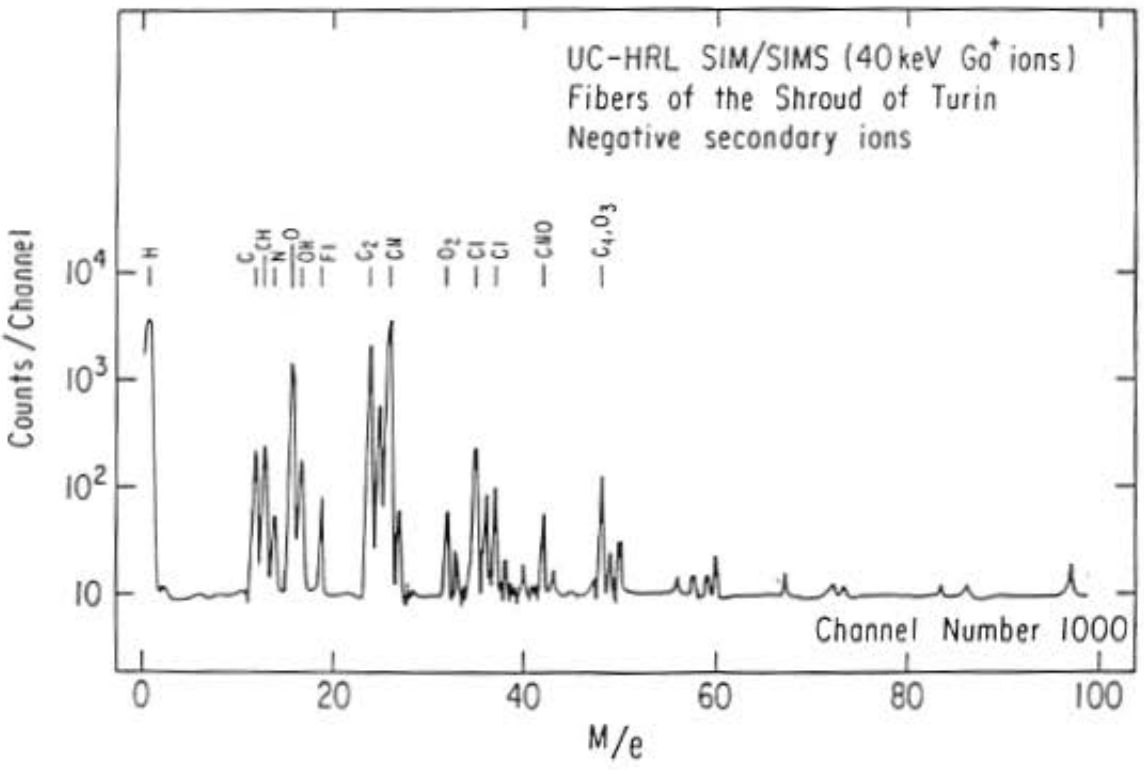

UC-HRL SIM/SIMS (40 keV Ga+ ions)
Limestone, tombs near Damascus Gate,
Jerusalem, Positive Secondary ions
H
Na
Mg
Al
K
Ca
K, CaH
Ca
CaO, Fe
CaOH
Ga
Counts / Channel
10^5
10^4
10^3
10^2
10
Channel Number 1000
0
20
40
60
80
100
M/e

Figure 66


UC-HRL SIM/SIMS (40 keV Ga+ ions)
Fibers of the Shroud of Turin
Negative secondary ions
Counts / Channel
M/e
Channel Number 1000

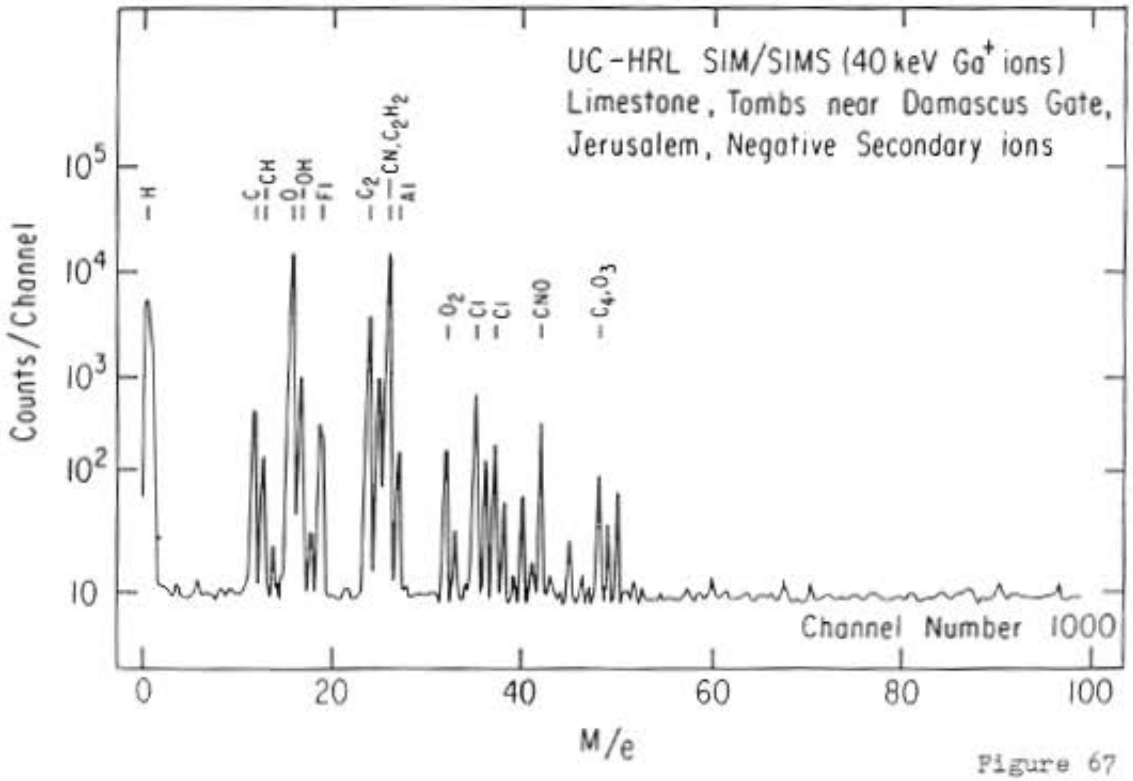

UC-HRL SIM/SIMS (40 keV Ga+ ions)
Limestone, Tombs near Damascus Gate,
Jerusalem, Negative Secondary ions
Counts / Channel
M/e
Channel Number 1000

Figure 67

Figure 68
École Biblique

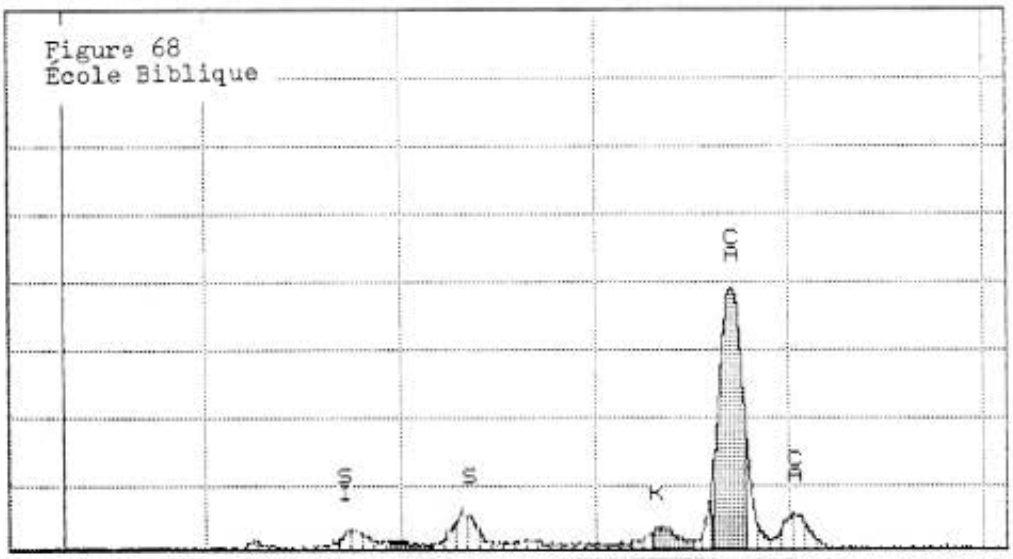


Figure 69
Emmaus

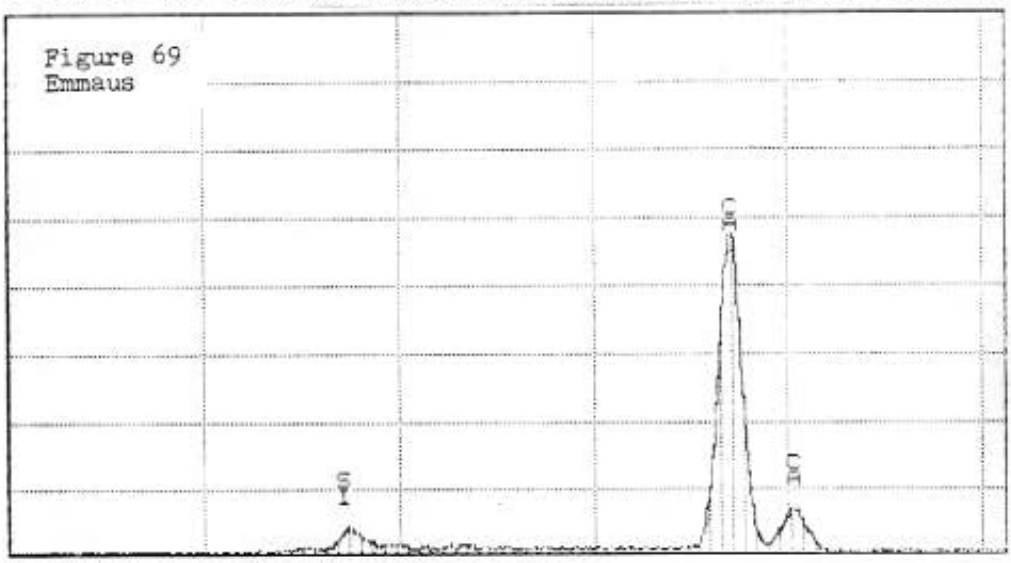
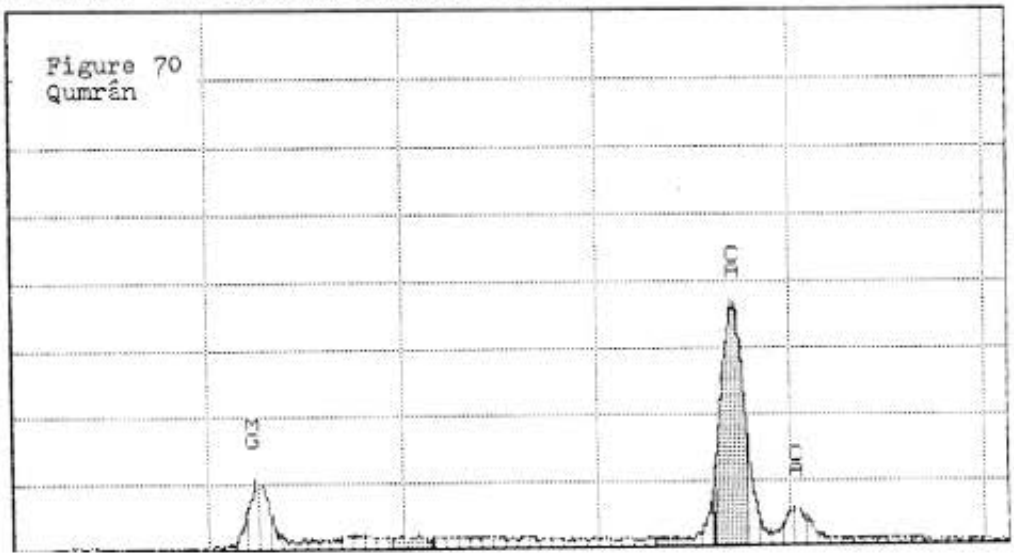
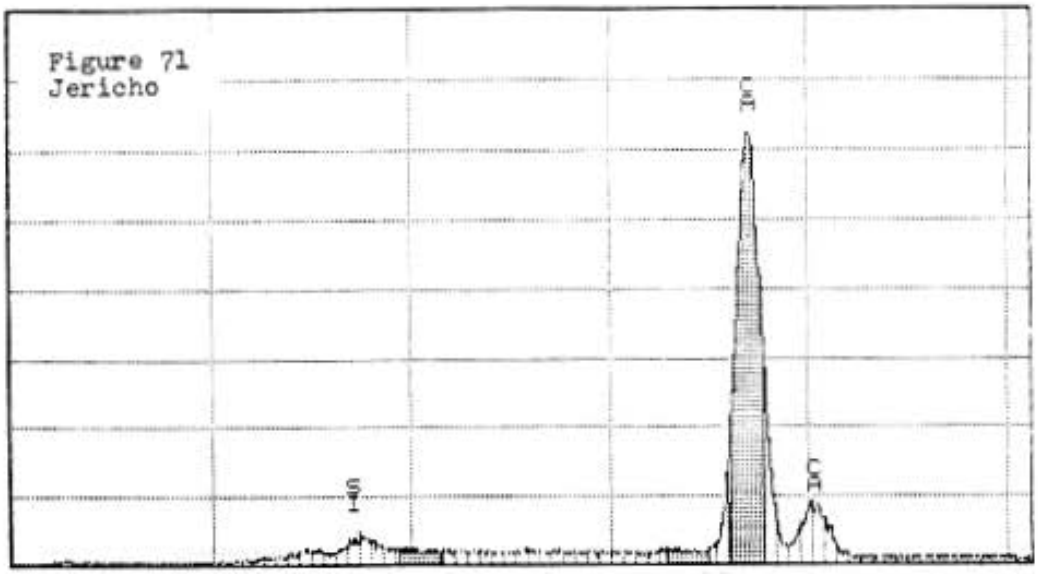


Figure 70
Qumrân

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Jericho

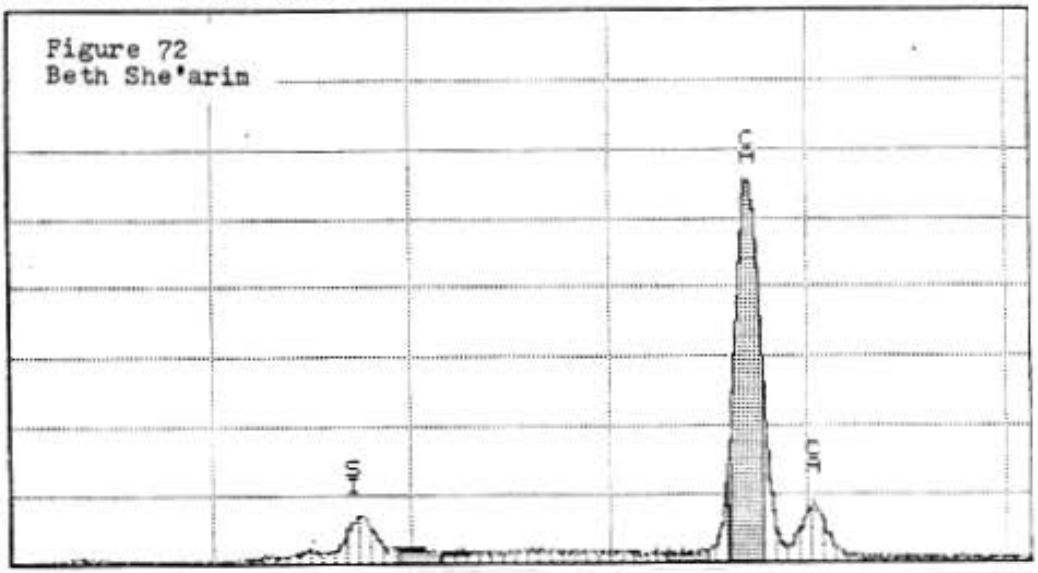


Figure 72
Beth She'arim

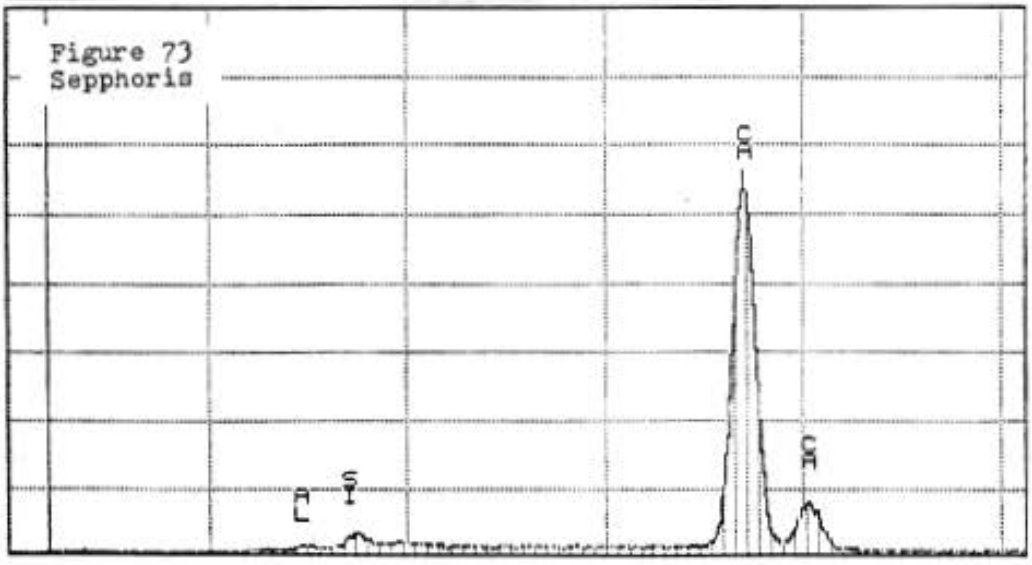


Figure 73
Sepphoris

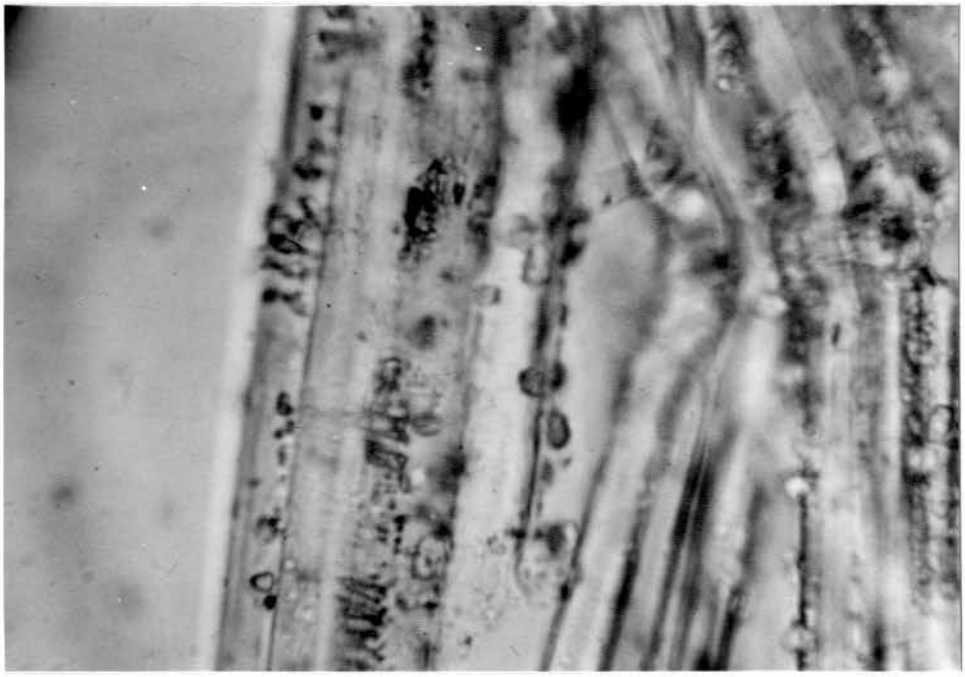
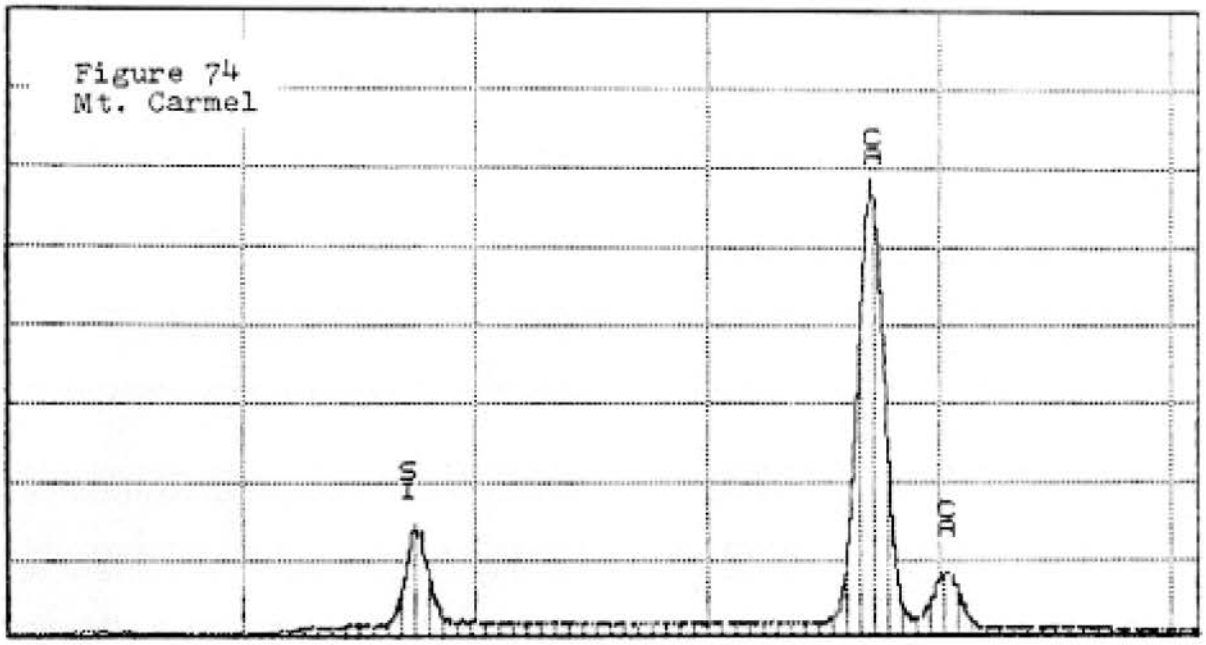


Figure 75, Modern linen treated with paste made from Jerusalem limestone and distilled water. Photo by Kohlbeck.



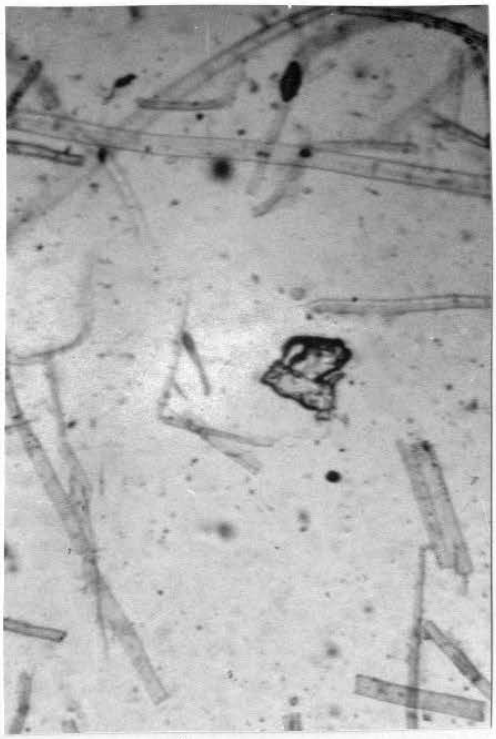


Figure 76, Shroud sample 1IB. Calcium and fibers. 100x by Damian.

Figure 77, Shroud sample 1IB. Calcium and fibers. 400x by Damian.

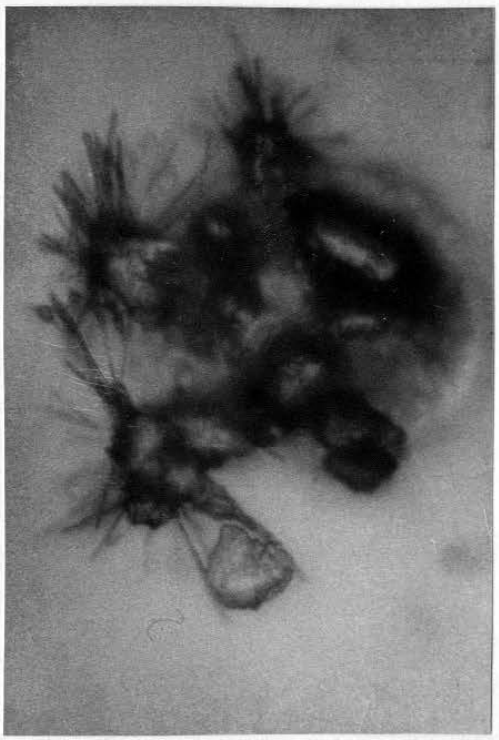


Figure 78, Shroud sample 4EB. Pollen and calcium. 400x by Damian

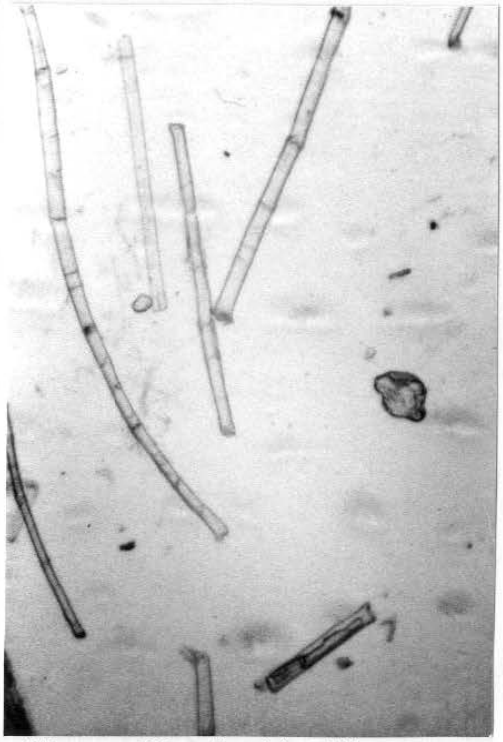


Figure 79, Coptic linen fibers and calcium. 100x by Damian.

CHAPTER 4

THE TOMB OF CHRIST

The New Testament describes the tomb of Christ as being new, carved out of the rock, and having a great stone roll in front of the doorway (Matthew 27:60, 28:2; Mark 15:46, 16:3, 4; Luke 23:53, 24:2; John 19:41, 20:1). There are two architectural types in tomb construction which use the rolling-stone closure. Both types are not only vastly different in style, but also date of manufacture, therefore, it is important to determine, archaeologically, the style of the type common to the time of Christ, so that the Shroud may be placed in its proper context. There are 61 rolling-stone tombs which have been documented and can be used for this purpose.(1)

The Mishnah, Baba Bathra 6:8 describes the style of tomb for the period in question, known as the kokhim type:

> If a man sold to his fellow a place to make a tomb...he must make the inside of the vault four cubits by six, and open up within it eight niches, three on this side, three on that side, and two opposite /the doorway/. The niches must be four cubits long, seven handbreaths high, and six wide. Rabban Simeon says: He must make the inside vault four cubits by eight and open up within it thirteen niches, four on this side, four on that side, three opposite /the doorway/ and one to the right of the doorway and one to the left.

Tomb F.31 at Tell Ḥesbân (biblical Heshbon)(2) seen in Figure 80 is a good representation of that description, especially with regard to the kokh at each side of the entrance, an uncommon find in current archaeological literature. The square, main chamber contains a pit in the center which creates a bench lining either three or four walls of that chamber. The burial niches, or kokhim (about .50m wide, 1m high, and 2m long), radiate from three walls around the chamber (or four walls in this case), and may vary in number according to both intended use and family wealth. Dating methods, primarily ceramic typologies, have placed this form of construction in the Early Roman period, 63 BC to AD 70/135.

An intermediate tomb form must be mentioned, not because it could contain a rolling-stone, since its architectural style makes that totally impossible, but because it fills the time gap between types that could. It is known as the shaft tomb and was used primarily during the Late Roman period, AD 135 to 325. This form is

composed of a rectangular shaft, roughly .50m by 2m, which extends down into the ground about 2m, opening into a square chamber divided by sunk (or trough) graves. Figure 82 illustrates the variations known in this style.

In Figure 83 one recognizes the model for the tomb most used to represent the type in which Christ was buried. It is known as the arcosolia type, because of the arches over the grave areas. Arches may cover either sunk (or trough) graves as seen in the Figure or ledges. Like the kokhim tomb, it too works off the square central chamber. This style is common to the Byzantine period, AD 325 to 640.

Another kokhim tomb from Ḥesbân, Tomb G.10,③ shows both a mixing of the kokhim and arcosolia types and provides valuable dating for the two forms of construction bearing out the correctness of the tomb typology. The basic kokhim construction dates to the Early Roman period, while the extended kokh which has two added arcosolia comes from the Byzantine period. See Figure 81.

Both the kokhim and arcosolia types may contain either the usual square stone slab entrance closure or, the more rare rolling-stone. The arcosolia type may even use a stone door on pivots.

The fact that there is a problem in the identification of the type used for Christ's tomb is due to the following reasons:
(1) The attempted destruction of the tomb by the Emperor Hadrian in 135, who filled it in, covered it over, and built a temple to Venus on top of it. This action, while removing it from view, protected it during a turbulent era, and the temple actually acted as the tomb's landmark.
(2) The tomb was destroyed in 614 by the Persians, allowing a period of only about 277 years between its discovery by Constantine in 337 and its first demolition.④ It was destroyed again under al-Ḥākim, Caliph of Egypt in 1009 and suffered no less than 37 earthquakes between AD 33 and 1834. In 1808 the substructures of the Holy Sepulchre were viewed for the last time and it was reported that the only living rock which could still be seen was part of a bench, the outline of the tomb itself having been obliterated long before.
(3) A fresco found in the baptistry of what is probably the earliest surviving Christian church during the excavations at Dura-Europos

which dated between AD 232 and 256, shows the earliest representation of Christ's tomb. It is portrayed as a free-standing sarcophagus with gabled lid, a representation totally unlike the New Testament accounts. By that time, the tomb had been covered for at least 121 years. It is surprising that the memory of the tomb could be so totally lost in a century.

(4) Up until the early 1970's, the majority of rolling-stone tombs which had been excavated were of the arcosolia construction. Therefore, the proper materials were not available on which to draw sound conclusions.

The most popular reconstruction for Christ's tomb is that proposed by Father Hugues Vincent, OP in 1914.(5) It is a double chambered tomb with an arcocolium over a single ledge. Vincent cannot be blamed for such a choice, since he had an arcosolia type rolling-stone tomb in the cloister of the École Biblique where he lived in Jerusalem, it was the most common form known from excavations in his day, and the ancient site of Gezer, whose excavation was being conducted at that time produced eight rolling-stone tombs all of this style.(6) Figure 84.

The kokhim type was long rejected as being the style for Christ's tomb, even though it was known to date from the correct period, because:

(1) It was thought that a body could not be seen from the doorway after having been placed in a kokh.

(2) The structure of a kokh made no allowance for the "two angels... one at the head, and the other at the feet, where the body of Jesus had lain," (John 20:12).

It is the bench in the central chamber which answers both of these objections. The body would hardly be placed in a kokh if the burial preparations were not yet completed.

Further evidence for the kokhim type being the correct style is the tomb behind the edicule in the Church of the Holy Sepulchre known as the Tomb of Joseph of Arimathea, Figures 2 and 3. Tradition says that Joseph did not want to reuse the tomb in which Christ was buried, so he built another near it. Whether this is accurate or not, the fact remains that a kokhim tomb is next to the traditional site and shows both the proper construction for the period and that the area was a cemetery.

Figure 85 shows a reconstruction I produced based on all the evidence from the New Testament, extra-biblical sources, and archaeological excavation.⑦

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② John J. Davis, "Heshbon 1976: Areas F and K," AUSS, Vol. XVI (Spring, 1978), pp. 129-148.

③ James Stirling, "Heshbon 1974: Areas E, F, and G.10," AUSS, Vol. XIV, No. 1 (1976), pp. 101-106.

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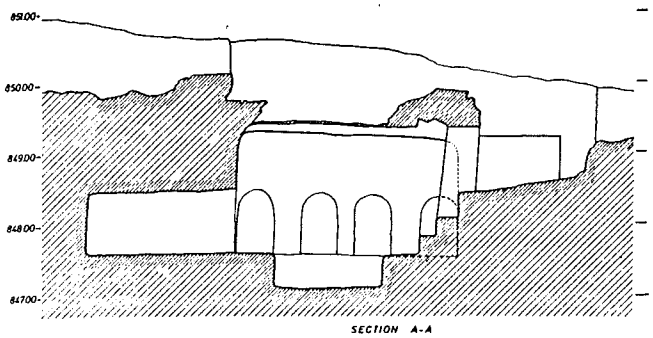
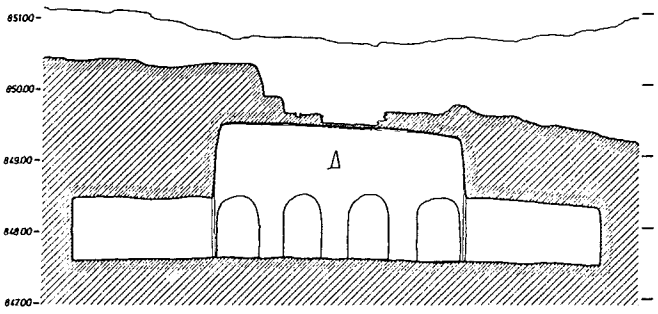
⑦ Including my own experience excavating rolling-stone tombs, see James A. Kritzeck and Eugenia L. Nitowski, "The Rolling-Stone Tomb F.1 at Tell Ḥesbân," AUSS, Vol. XVIII, No. 1 (Spring, 1980), pp. 77-100.



SECTION A-A



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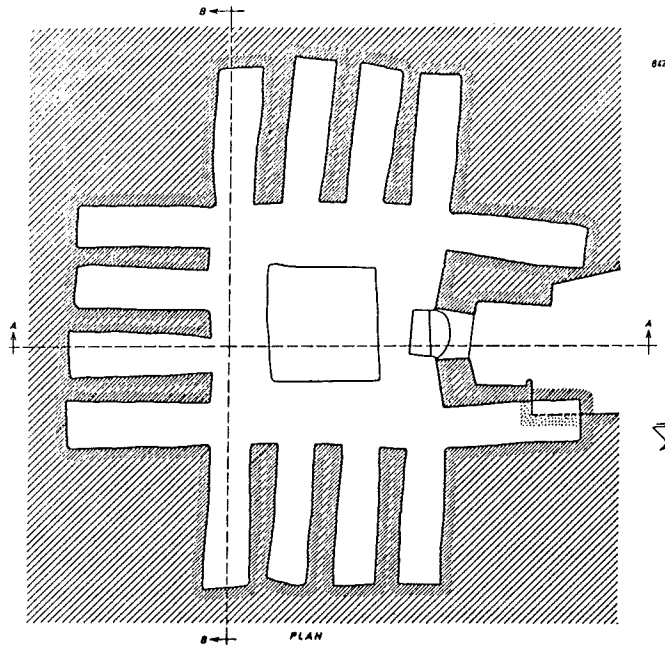


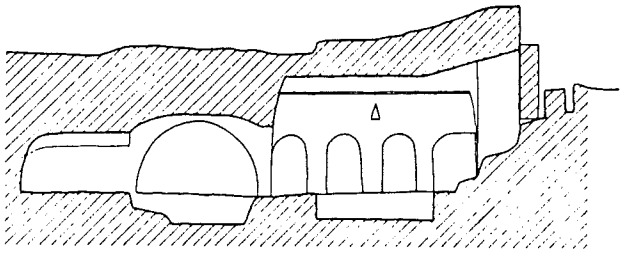
PLAN

HESHBON 76

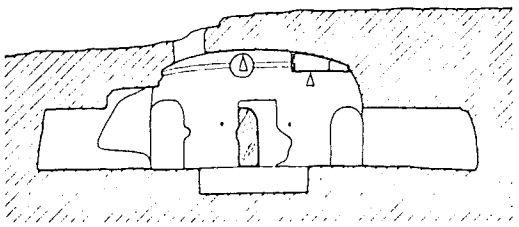
AREA F TOMB 31
DRAWN AUGUST 7 1976
BY MERLING ALOMIA
DAVE PIPER
ANITA VAN ELDEREN

SCALE METERS
0 .40 .80 1.20 1.60 2.00

Figure 80



SECTION A-B



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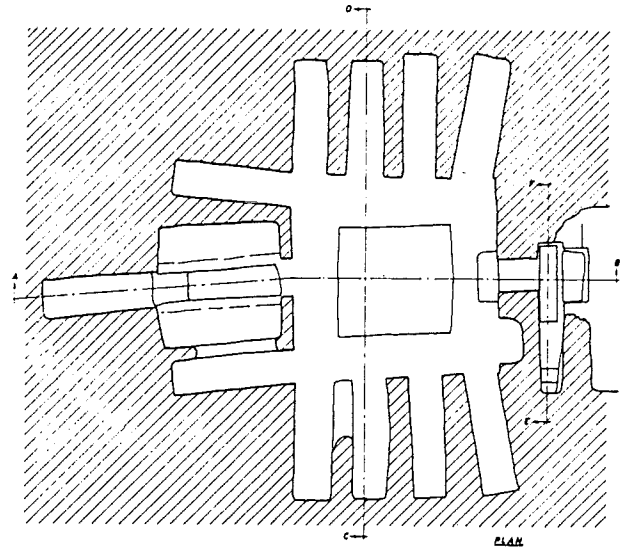
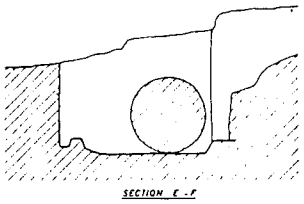


PLAN



SECTION E-F

HESHBON 1974

AREA G.10 "ROLLING STONE TOMB"
DRAWN AUGUST 9 1974
BY BERT DEVRIES

SCALE METERS
0 .40 .80 1.20 1.60 2.00

Figure 81

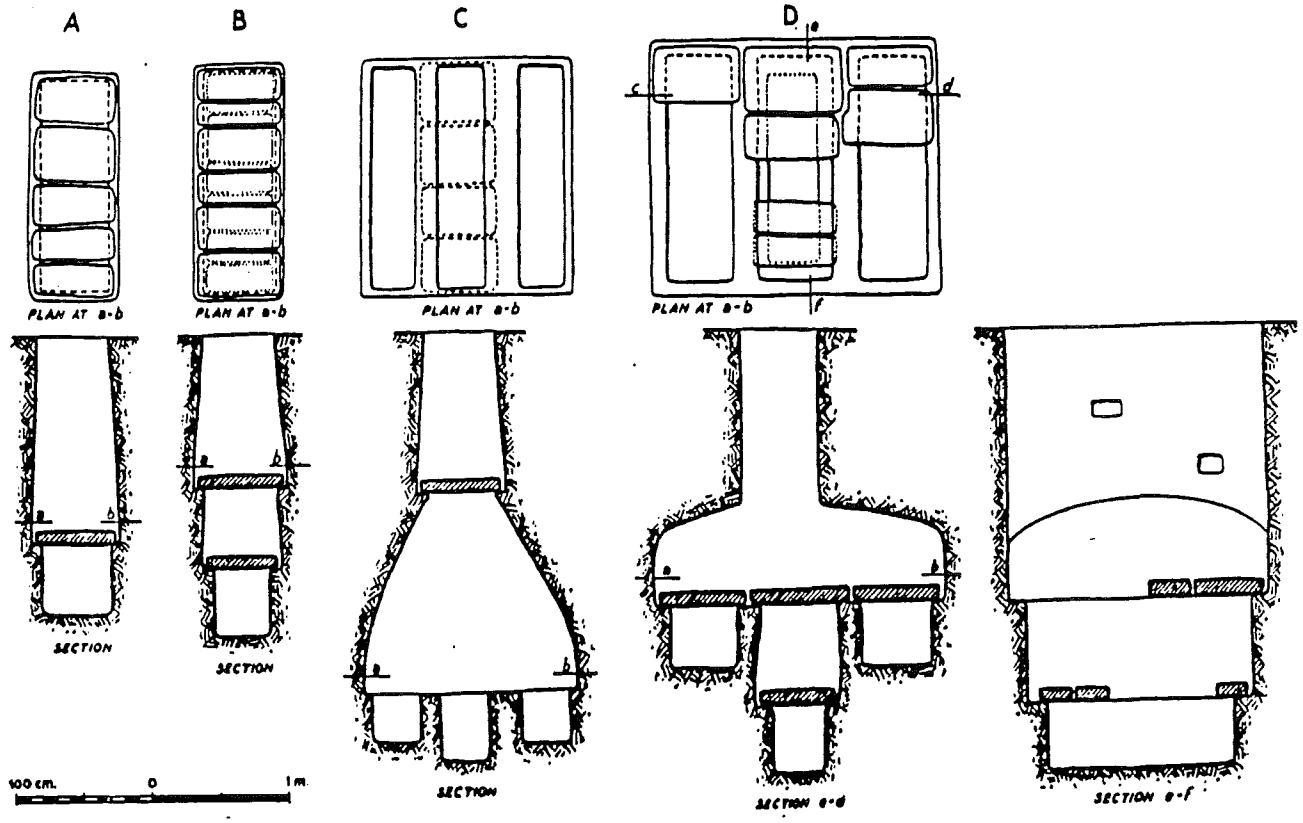


Figure 82

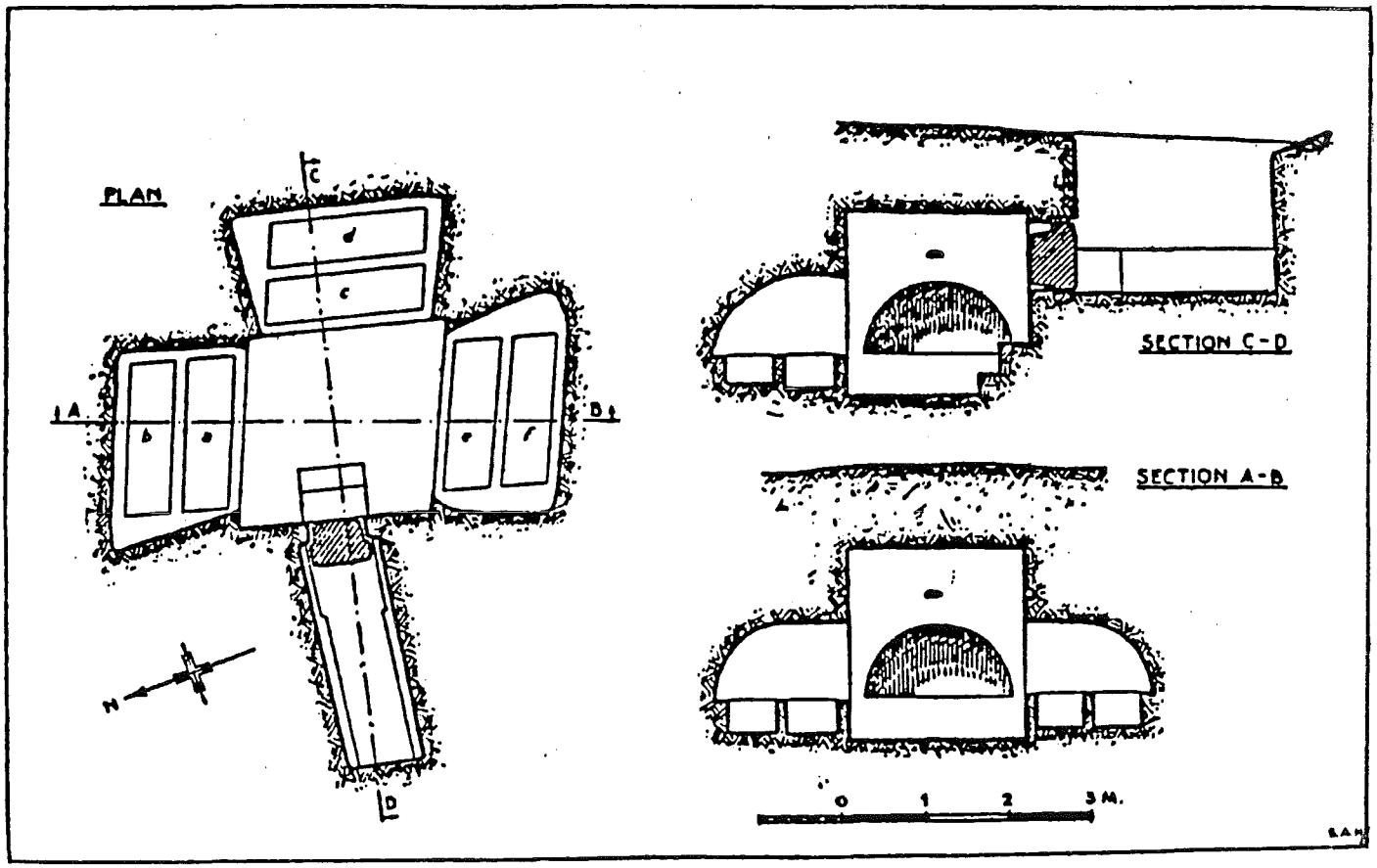


Figure 83

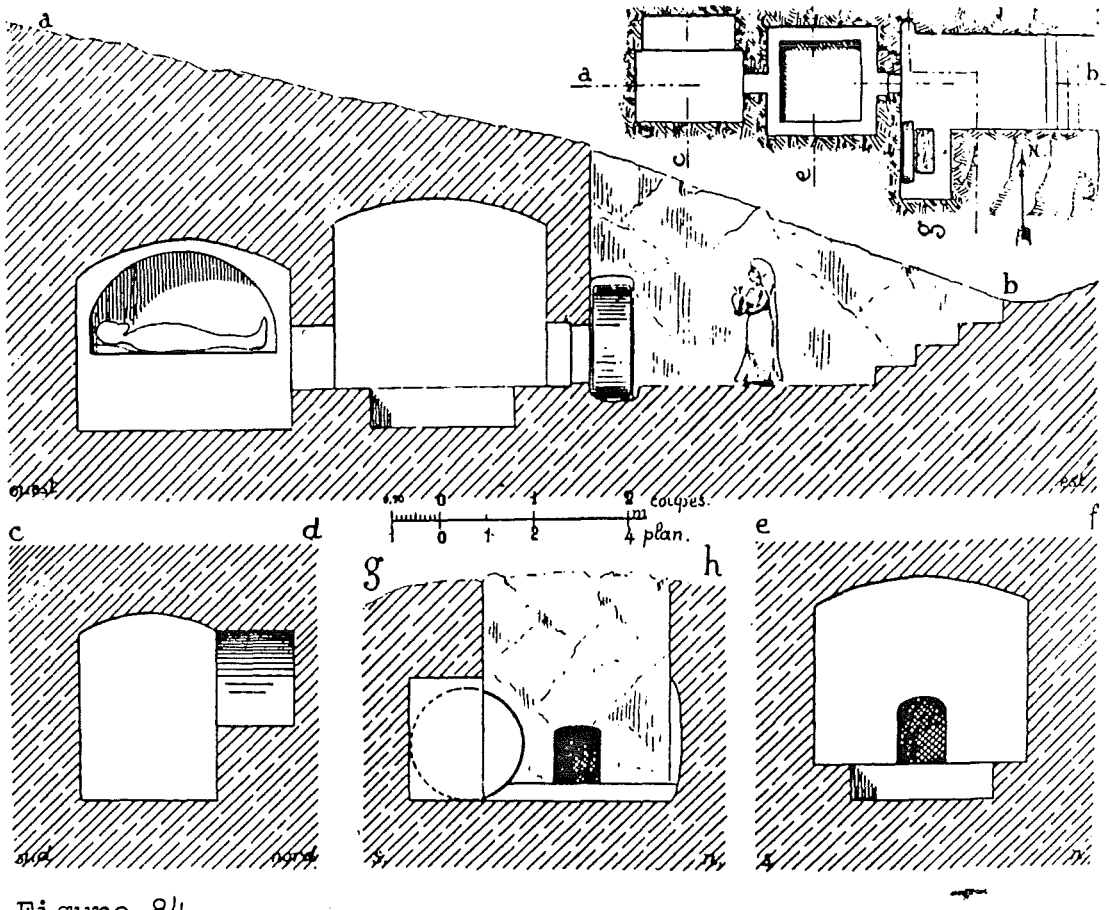


Figure 84

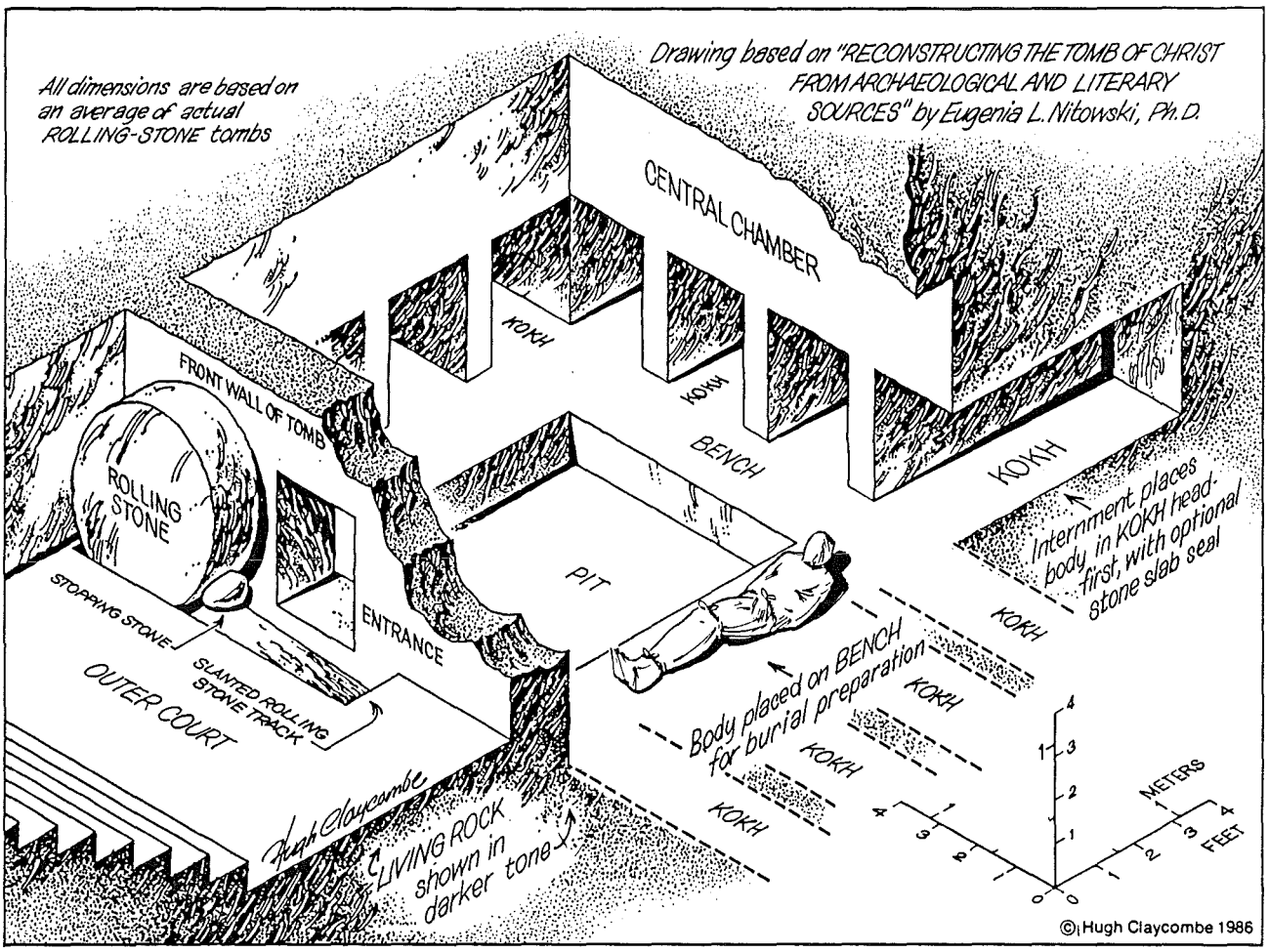


Figure 85

CHAPTER 5

MYRRH AND ALOES

In a paper written in 1981 by Dr. Giovanni Riggi,[1] natron was reported as being found on the Shroud. Natron is a hydrated native sodium carbonate ($Na_2CO_3 10H_2O$), which was employed, mostly in Egypt, during the embalming process.

Dr. Pierluigi Biama Ballone and Dr. Agostino Gaglio, on the other hand, in a 1984 article[2] discussed their findings of myrrh and aloes on the Shroud. In 1985, when I received the Mylar tapes and began photographing them, I too found myrrh and aloes, as shown in the comparative photos of Figures 86a and 86b; 87 and 88. The study could go no further, because of the inability to perform testing which would either remove or destroy materials from the tapes.

Professor Umberto Fasola gave a report[3] in 1978 at the Second International Congress of Sindonology in Turin about archaeological discoveries which have a bearing on the problems connected with the Shroud. In that report, he gave evidence for the use of myrrh and aloes in a Jewish tomb found in the catacombs in Rome. The mixed substance had been applied to walls and the bodies. At first, this seemed like an invalid comparison, since nothing of this sort had been found in tombs either in Palestine or Transjordan. When I inquired about the matter with other biblical archaeologists who had considerable experience in the excavation of ancient tombs, they too said that they had no knowledge of such a practice.

During the April testing, time was taken to sample tombs for the possible identification of such an additive to the interior surfaces. Because a compound of "burial spices" would be purely a surface contaminant, sticky-tape was used to lift only a thin layer from different areas in the tomb which seemed to be the most likely to receive such treatment. Seven tombs were sampled:

1- The big tomb complex used for the tests (8th/7th century BC);
2- The rolling-stone tomb in the cloister (Byzantine period); and
3- The swinging-door tomb in the cloister (Byzantine period), all at the École Biblique in Jerusalem.
4- Garden Tomb (8th/7th century BC?), next to the École in Jerusalem.
5- The large kokhim tomb (Early Roman period); and
6- The square chambered tomb, which cut into the kokhim tomb (Byzantine period), both from Sepphoris.

7- The catacomb type with chambers containing arcosolia (2nd century AD) at Beth She^{c}arim.

Upon microscopical examination of the tapes, a resinous, non-crystalline material was found mixed with the limestone. The resinous substance was found to be only on the surface. In the tomb complex we used for testing at the École, the applied material was found when the chamber used for the image tests was brushed to remove visitor debris and ceiling-fall. The material darkened considerably when a fine mist of pure water was sprayed into the chamber in an attempt to raise the humidity. In this case, Figure 89, the substance is quite thick, and aside from the limestone which adheres to the top and bottom surfaces, shows layering itself, hinting at repeated application. Figures 92 to 96 illustrate its use in the tomb. Figure 93 shows its application over the bench and extending up the walls approximately 20cm. The stairs, Figure 92, are covered as well as the sides of the benches, Figure 94; around the entrance to the bone repository, Figure 96; and from the floor part way up the wall in the bone repository, Figure 95.

The Garden (Gordon's) Tomb also exhibited the same substance in the thick layered form in the trough graves, Figures 97 and 98. The substance is always a dark-brown (Figure 89) to amber to reddish-amber, Figure 90.

The highest concentration is, of course, the thick layers in the École tomb complex and the Garden Tomb, both approximately 8th/7th century BC. The kokhim tomb at Sepphoris showed the next highest concentration, Figure 91. The École Byzantine rolling-stone and swinging-door tombs as well as the Byzantine tomb at Sepphoris showed a lesser amount, while the Beth She^{c}arim catacomb contained the least. It appears as though the older the tomb, the higher the concentration, but the Beth She^{c}arim catacomb has a slightly earlier date than the above mentioned Byzantine (AD 325-640) tombs.

A parallel to such a substance can be found in the Giv^{c}at ha-Mivtar report by the late Dr. Nicu Haas:(4)

> A syrupy fluid was found filling the lower third of 13 ossuaries. The bones and other material immersed in this fluid were coated with a limy sediment. On the surface of some bones dark-brown blotches were occasionally observed, or even a thick, adherent black-brown crust....The special nature of the skeletal remains in eight ossuaries - people who had died from illness or

> violence - was recognized during reburial, as indicated by external evidence which singled them out from those who had died from natural causes. This feature was the presence of dark-brown blotches, probably from oil, on those bones which had been damaged by violence or disease, which injuries were the most likely cause of death.

I would question the identification of the substance as oil, because it generally breaks down in time. Seldom has any trace of oil been found on ancient ceramic oil lamps. If oil was used, perhaps it was ~~the was~~ used for the mixture of "burial spices."

The next step was to ascertain if the brown-amber surface material found in the tombs was myrrh and aloes. Myrrh, in Arabic meaning "bitter," is a bitter-tasting, agreeably aromatic, yellow to reddish-brown oleoresinous gum obtained from various small, thorny, flowering trees of the genus Commiphora, or the incense-tree family Burseraceae, as C. myrrha or C. abyssinica. It was used by the ancients as an ingredient of costly incense, perfumes, and cosmetics, and was used in medicines and in embalming. Myrrh is exuded as a fluid from resin ducts in the tree bark when the bark splits naturally or is cut in tapping. Upon exposure to the air, myrrh hardens slowly into globules and irregular lumps called tears. Myrrh contains 25 to 45 percent resin, 3 to 8 percent essential oil, and 40 to 60 percent gum. Aloes is the dried, bitter, resinous juice prepared from the crushed leaves of various species of Aloe. The genus Aloe belongs to the lily family, Liliaceae. The Curaçao Aloe contains 18 to 25 percent aloin (curaçaloin) and Cape Aloe 4.5 to 9 percent aloin (capaloin); all aloes contain resin, emodin, and volatile oil. Aloe yields not less than 50 percent of water-sol extractive.

Kohlbeck ran a sample from the bench of test chamber 2 through the electron microscope with the results given in Figure 100. Large quantities of limestone (Ca) coated each side of the layered substance as seen in Figure 89. The high phosphorus (P) content could be explained by the prolonged contact with bones on the bench. The sample was then tested with the infrared spectrometer and showed the substance to be an inorganic, Figure 99. Myrrh and aloes gave organic readings in Figures 101 and 102. Figures 103 and 104 show aloes mixed with limestone from the tomb and myrrh, aloes, and tomb limestone, which I then heated for several hours to see if any change would occur, such as the breakdown of the organic. While a

change did take place, it does not match the substance in the tomb at the École Biblique. This does not mean that myrrh and aloes were not used as the material to prepare the walls, since we were able to check the substance from only one out of seven tombs sampled and the tomb sampled by Professor Fasola definitely used myrrh and aloes. Such substances were also definitely used in the preservation of the body in ancient times.(5)

Our discovery of this substance in Palestinian tombs along with the observations of Haas at Giv^{c}at ha-Mivtar with the material reported by Fasola may explain the use of such a large amount of myrrh and aloes described in John 19:39 in connection with the burial of Christ. First, since the tomb was new and never used previously, the walls, benches, and kokhim were probably not treated with the "spices," and a large quantity would be required for such a tomb. The use of myrrh and aloes on tomb surfaces would, no doubt, be to mask any unpleasant effects of burials when the tomb had to be re-entered, since such tombs have a history of family use for centuries. Second, the fact that Christ died a violent death, may have indicated the kind of treatment found on bones at Giv^{c}at ha-Mivtar. Perhaps such treatment was given to the body at initial interment. Third, both myrrh and aloes are mild acids and acid can be a preservative. Since Christ's body could not undergo complete preparation for several days, His body could have been packed with some of the myrrh and aloes until all was complete.

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(2) Nicu Haas, "Anthropological Observations on the Skeletal Remains from Giv^{c}at ha-Mivtar," IEJ, Vol. 20, Nos. 1-2 (1970), pp. 38 and 39.

(3) Giovanni Riggi, "The Dusts of the Holy Shroud of Turin," Progress report on the work of the Turin Section of STURP, New London, Connecticut, October 9, 1981, p. 5.

(4) Pierluigi Biama Bollone and Agostino Gaglio, "Demonstration of Blood, Aloes and Myrrh on the Holy Shroud with Immunofluorescence Techniques," Shroud Spectrum International, No. 13 (December, 1984), pp. 3-8.

(5) R. Pfister, Textiles De Palmyre (Paris, 1934), and Rosalie David, editor, Mysteries of the Mummies (London, 1978), p. 144.

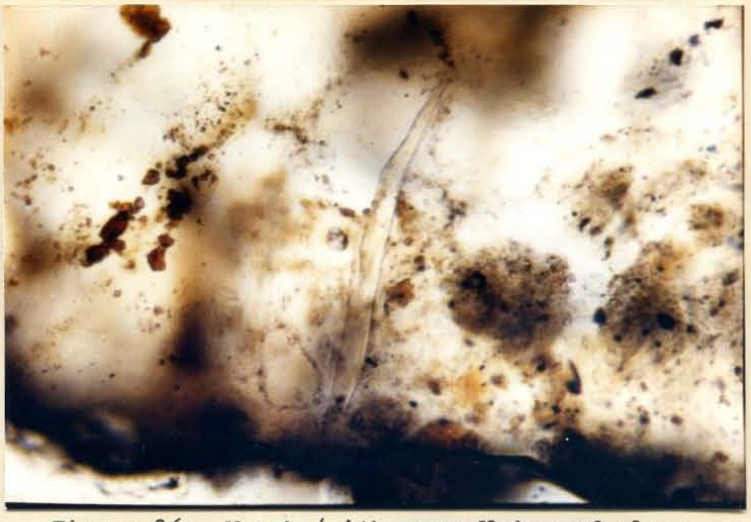

Figure 86a, Myrrh (with some flakes of aloes seen at the left) from the Shroud, sample 1FH. Photo by Kohlbeck.

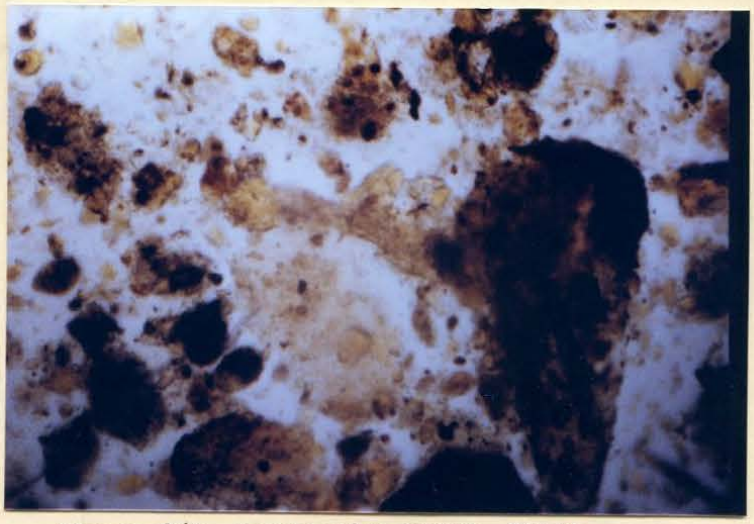

Figure 86b, Comparative myrrh. Photo by Damian.

Figure 87, Aloes from the Shroud, sample 1FH. Photo by Kohlbeck.

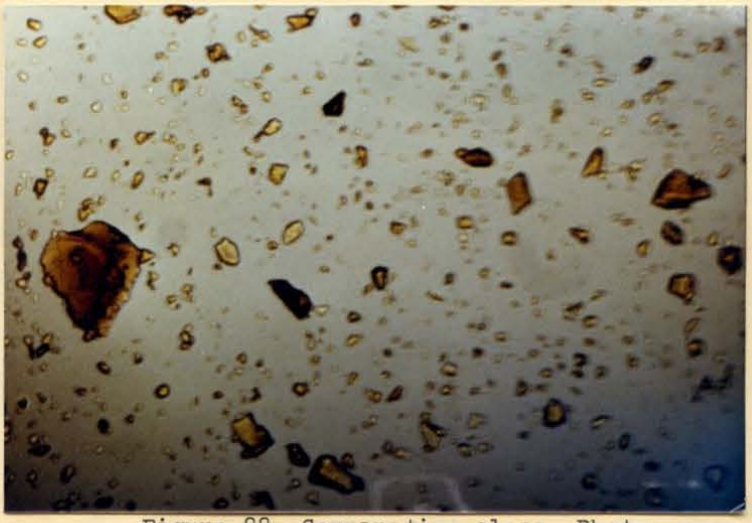

Figure 88, Comparative aloes. Photo by Kohlbeck.

Figure 89, Dark brown substance applied to the bench in test chamber 2. Photo by Kohlbeck.

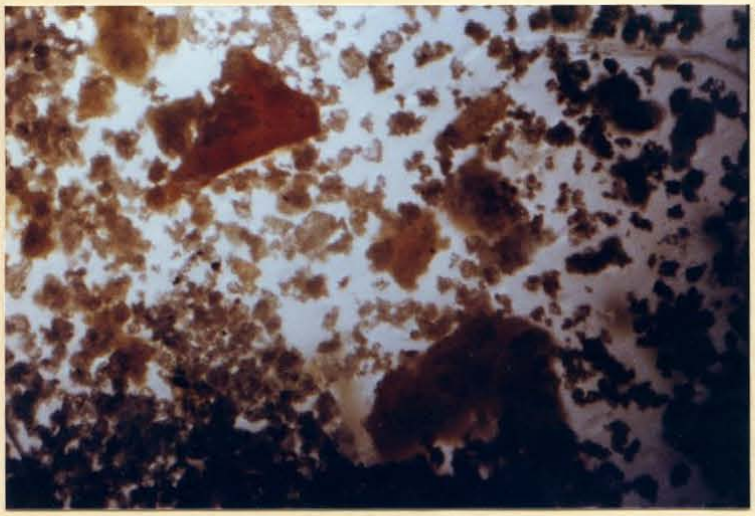

Figure 90, Tape sample from trough in Garden Tomb. Photo by Damian.

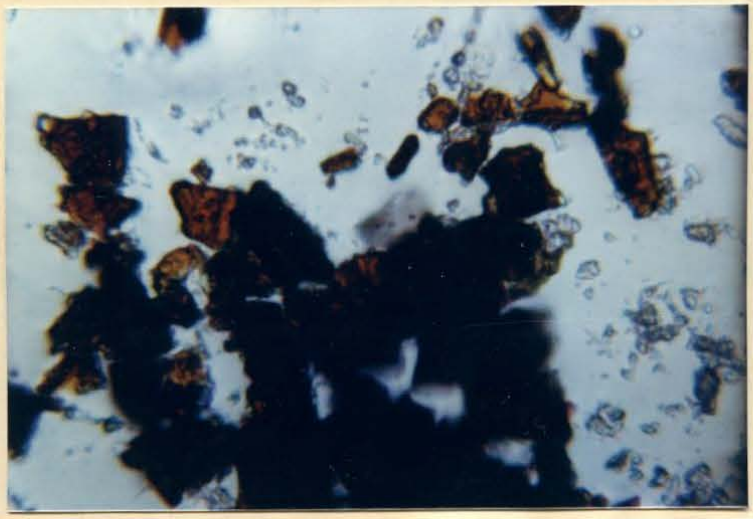

Figure 91, Tape sample from wall in Early Roman kokhim tomb at Sepphoris. Photo by Kohlbeck.

Figure 92, stairs to bench in test chamber 2.

Figure 93, Bench and headrest, test chamber 2.

Figure 94, Benches and head rest in test chamber 2.

Figure 95, Bone repository.

Figure 96, Opening under bench for bone repository.

Photos by Damian

Figure 97, Center trough grave in the Garden Tomb, showing applied substance. Photo by Damian.

Figure 98, Detail of material applied to trough grave. Photo by Damian.

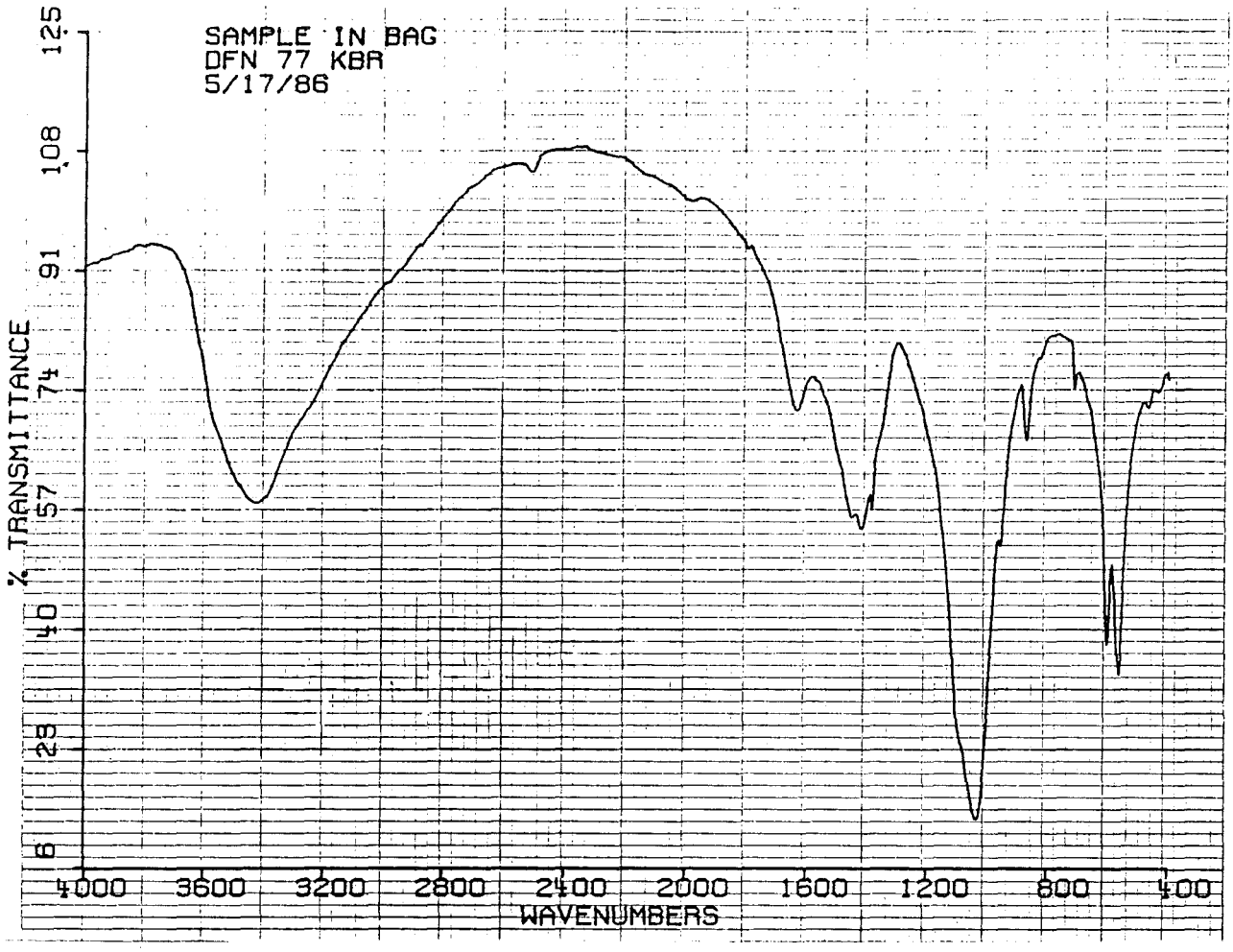

Figure 99

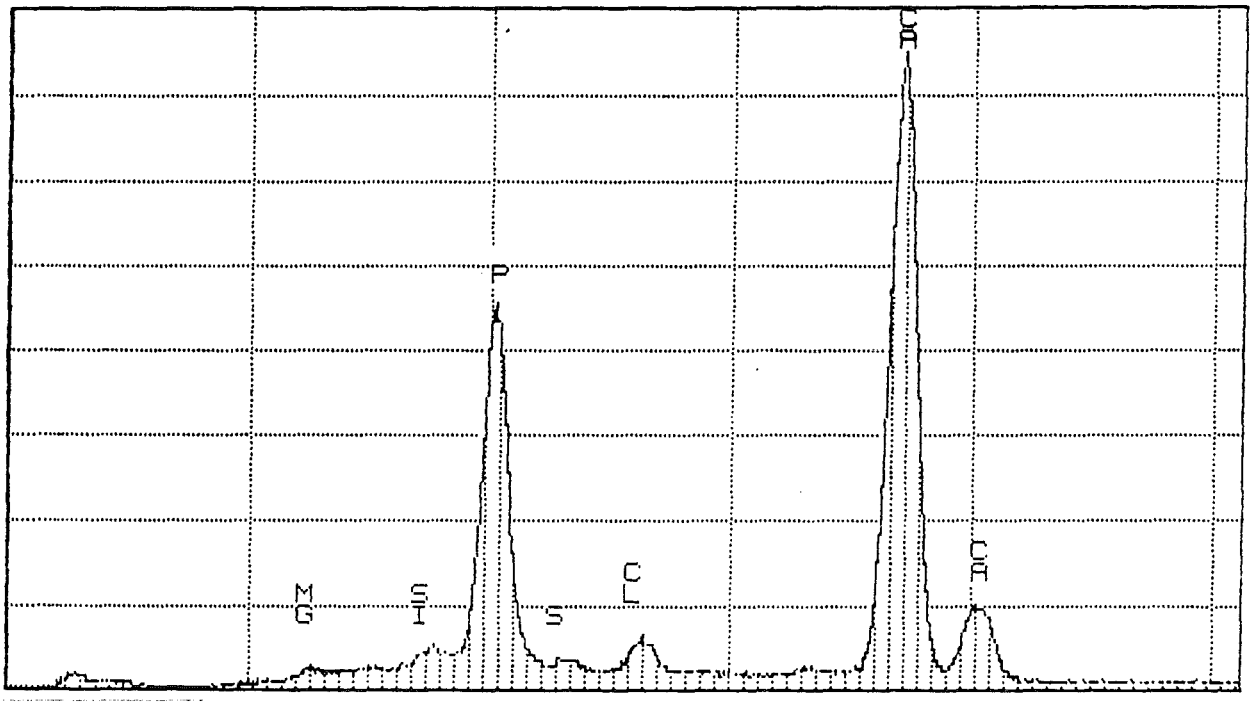

Figure 100

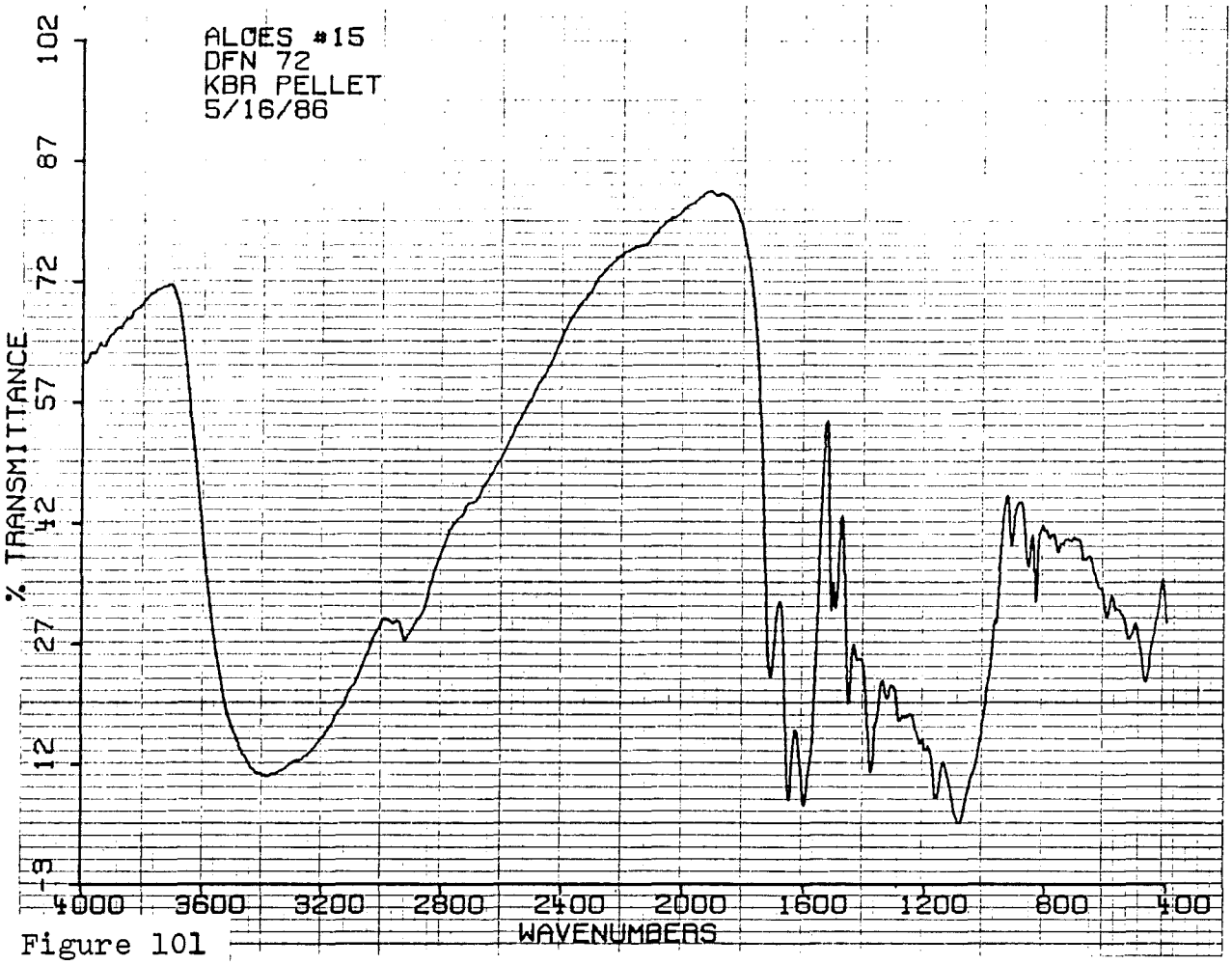

Figure 101

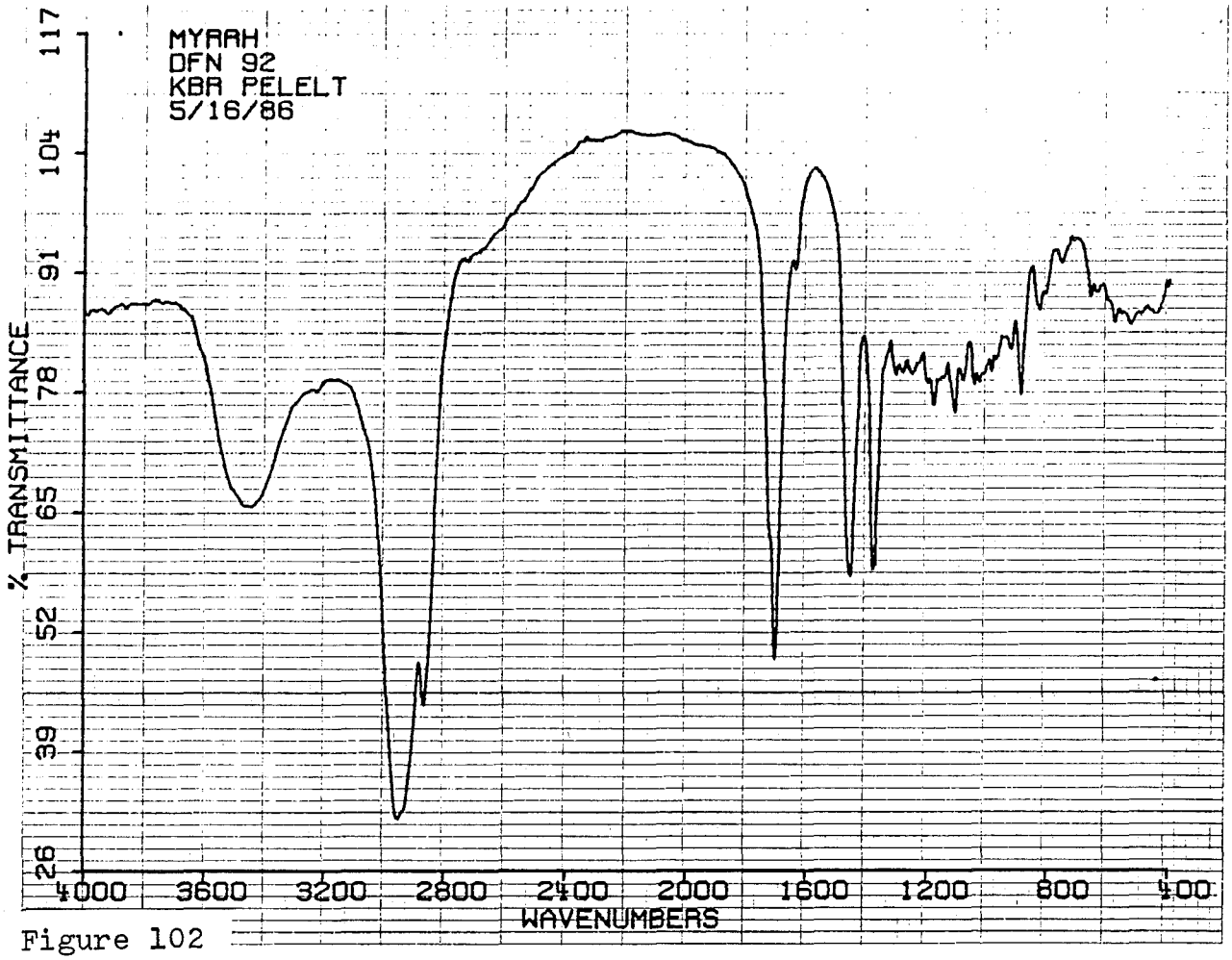

Figure 102

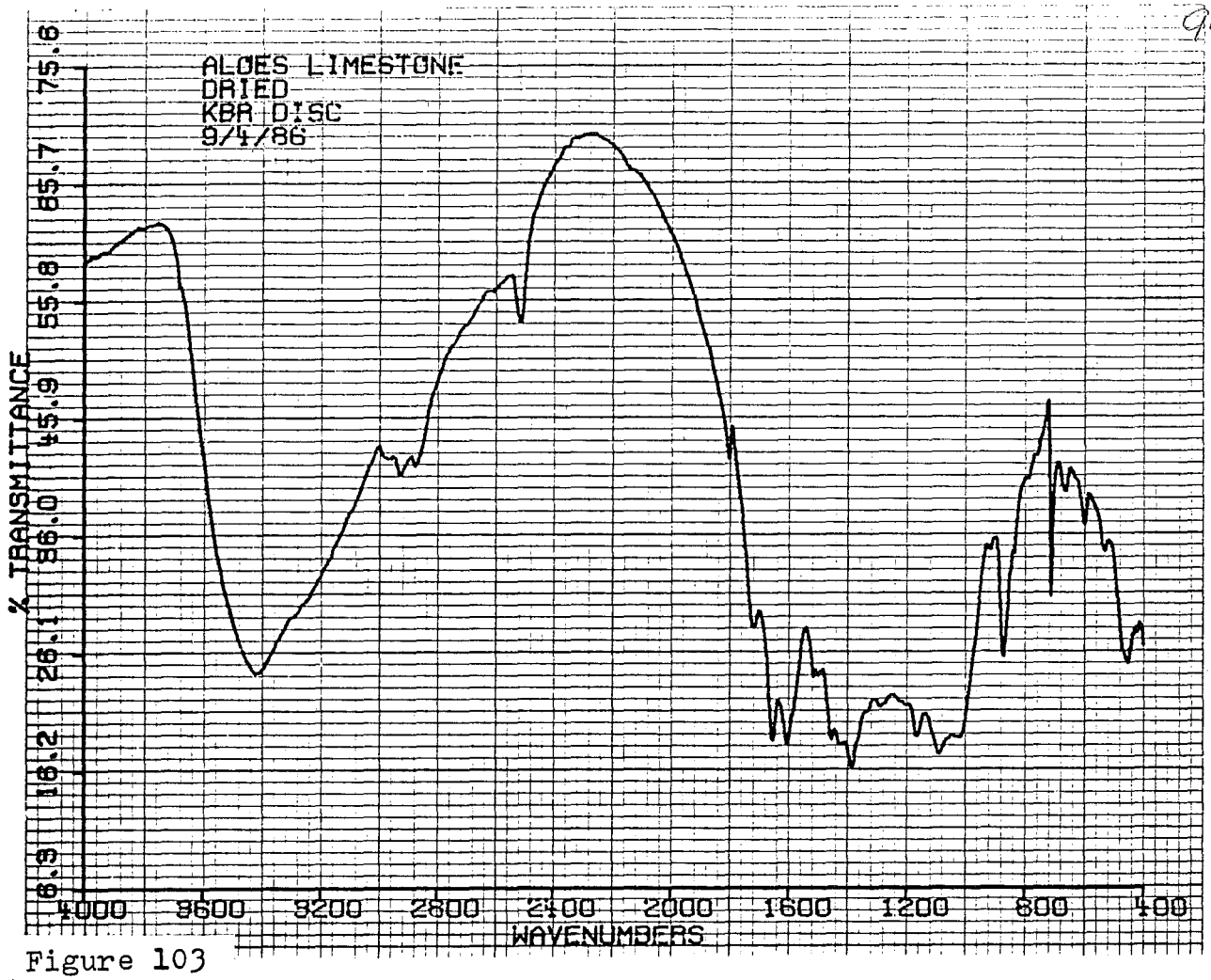

Figure 103

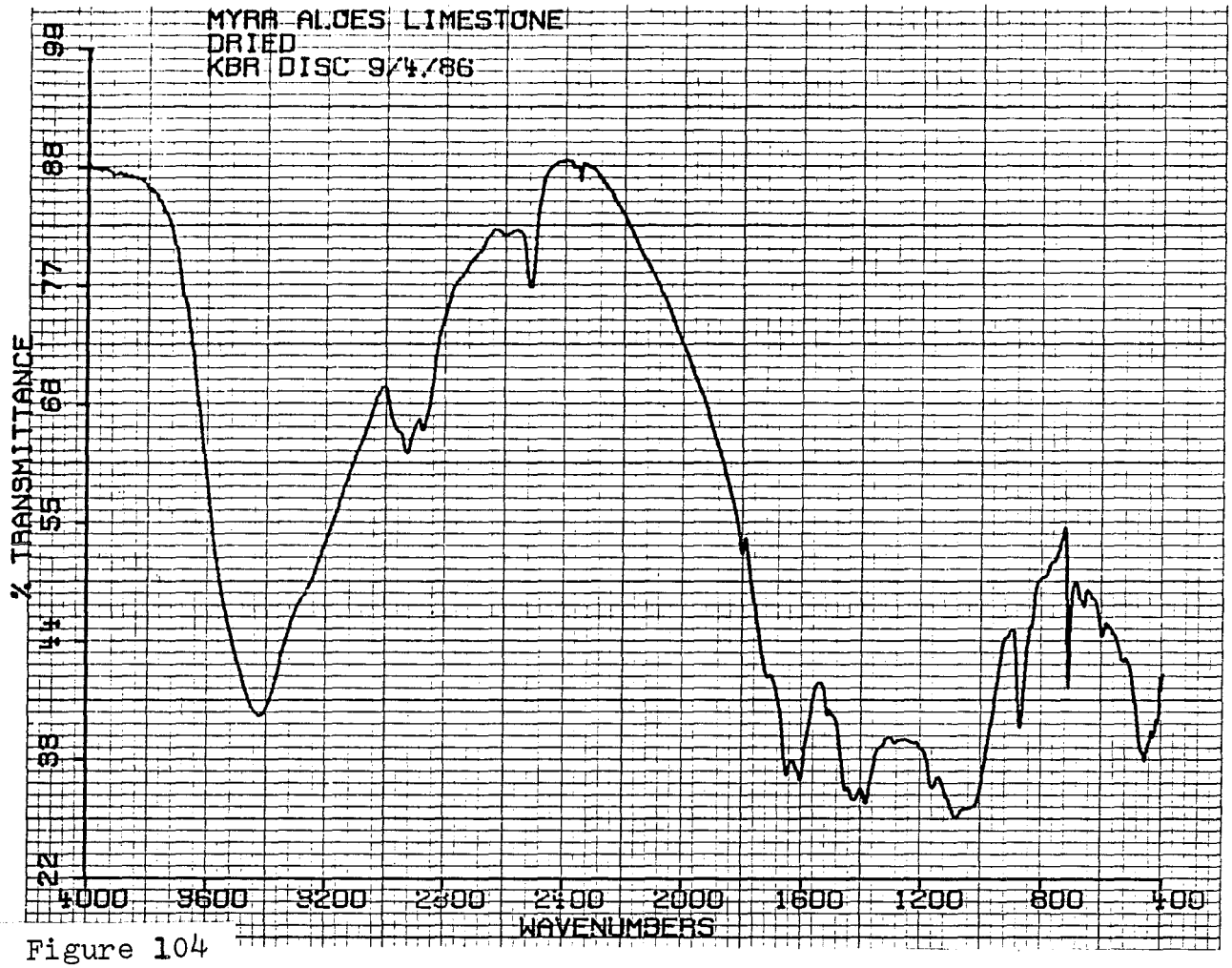

Figure 104

CHAPTER 6

SKELETAL ANALYSIS

Perhaps the best way to gain ground for sindonology is to put archaeologists on the defensive. It is clear from the lack of evidence for crucified individuals that excavation techniques are inadequate. The best illustration of this is the 1968 discovery of the remains of the crucified man at Givᶜat ha-Mivtar in Jerusalem. Of the thousands of individuals crucified in the Early Roman period (63 BC to AD 70/135) alone, the excavation and analysis of only one seems ludicrous. Explanation has been given citing the fact that at one time, the iron nails used in crucifixion were taken from the victims and used as remedies for a variety of ailments, thus providing no evidence.(1) A more realistic answer lies in the fact that the excavation of most tombs is a salvage operation brought on by chance finds during construction. Salvage is generally hurried and capable physical anthropologists cannot always be found and even if they are, a further time restriction is often placed on them by religious authorities.(2) Few archaeologists are trained in tomb excavation which is vastly different from that of the Tell. Skeletal material is usually in poor condition, so that damage inflicted on bones at death cannot always be distinguished from that which occurs later. What is perhaps most discouraging of all is that archaeologists have not always used physical anthropologists and undoubtedly large quantities of valuable material have been lost.

CRUCIFIXION Greater attention must be given in the future to the skeletal material itself, now that a list of telltale signs are accumulating in which to judge the cause of death. We might begin a list of criteria for crucifixion by the use of the Givᶜat ha-Mivtar remains: (1) The presence of iron nails in or closely associated with the skeleton. (2) Broken leg bones. (3) Amputated feet. (4) Scratches in the lower portions of the radius and/or ulna of the arms. Numbers 1 and 4 could be taken alone, while 2 and 3 must be in combination with another.

The remains of Yehohanan of Givᶜat ha-Mivtar were found in an

ossuary.(3) The ossuary is a most characteristic object found in Jewish tombs. It is a small limestone box with a lid and is used as a container for the reburial of an individual's bones. Many times these boxes carry inscriptions relating the person's name, origin, occupation, and circumstances of death. One scholar has suggested that certain cross marks found on ossuaries may indicate that the person died of crucifixion. One with such a cross mark even bears the inscription of grief, "Jesus Woe!"(4)

Evidence for iron nails associated with skeletal remains are found in another ossuary which also comes from Giv^{c}at ha-Mivtar from the Abba cave.(5)

> Two iron nails were found in association with the phalanges. One had the base of a proximal phalange adhering to it. The second, which was bent, had a proximal phalange adhering to one side and a medial phalange to the other side. In neither case had the nail perforated the bone. A third nail was also present, but no bones were in contact with it.

The skeleton was determined to be that of a woman, who suffered at least two blows by a sword which passed through the mandible, possibly after death. The presence of an arthritic condition and ante mortem tooth loss suggest an older age. Because of associated objects, the date of reburial in the ossuary is thought to be 37 BC.

It seems unlikely that the iron nails in this case could have come from a coffin. We have no evidence that secondary burial into an ossuary from a coffin existed. If it did, it is a considerable step from nails used in the joints or as decoration on a coffin to the hands, which were either at the sides of the corpse or folded over the pelvis, and that nails would fall one to each hand seems more than coincidental. Hachlili and Killebrew point out that, "Iron nails, which in the past were considered to be proof that wooden ossuaries existed, were not used in the construction of wooden containers."(6) And that at Jericho, coffins were made of wood and wooden pegs, iron nails and knobs may have been only for decoration.(7)

That nails were adhering to finger bones should not lead one to the assumption that the nails were originally placed in the palm of the hand, since various types of materials will adhere during corrosion or decay upon prolonged contact whenever that contact occurs. Unfortunately, the arm bones were not in good enough condition for

detailed analysis. The only reason that this find was not considered a victim of crucifixion was that the iron nails did not penetrate the bone. This is not a logical conclusion, since in the case of Yehohanan, the only bones pierced by the nail were the ankles and these are missing from the "Abba woman." A "possible 'magical' practice may have been the placement of nails with the burial, an interpretation first suggested by Kurtz and Boardman in an attempt to explain the occurance of nails in funerary contexts at Olynthus. A later rabbinic source which speaks of throwing iron between or in the tombs against spirits, may also support this interpretation."(8) But in the case of the "Abba woman," why three?

A further source from the Mishnah (Shabbath 6:10) states about "medical" objects which could be carried on the Sabbath,

> Men may go out with...a nail of one that was crucified, as a means of healing. So Rabban Meir. But the Sages say: Even on ordinary days this is forbidden as following in the ways of the Amorite [or heathen superstition].

This text seems to indicate that the use of nails, whether for medical purposes or against spirits, might not be as widespread as some might believe, but rather actual evidence for crucifixion, since their use was considered pagan.

A third example comes from excavations under St. Peter's Basilica in Rome. Professor V. Correnti thoroughly examined the skeletal remains believed to belong to the Apostle Peter, and the following was given:

> There has been little or no comment on this peculiarity...the total absence of the bones below both ankles. That these pieces might have been lost because of their small size is no answer.... One possible explanation, admittedly beyond proof, does leap to mind: Might there not be some link between the missing foot bones, and the tradition that Peter was crucified head downward? With his feet nailed to the upper part of the cross, whether separately or together, Roman executioners in removing the body certainly would not have hesitated to sever the feet, should the extraction of the heavy nail or nails from the wood have proved at all difficult(9)

It may be possible to conclude from this and the woman from the Abba cave, who also exhibited a total lack of bones from the feet, that the amputation of the feet after crucifixion, as with Yehohanan, is not an unusual instance, but rather, a standard method for the removal of a crucified body from the cross. If this is so, Psalm 34:20 referring to the fact that none of the Messiah's bones were

to be broken is amplified to the point that neither were they severed!

A reappraisal of the crucified man from Givᶜat ha-Mivtar by Joseph Zias and Eliezar Sekeles[10] will not long bear up under critical examination. Dr. Nicu Haas is dead and therefore cannot defend his analysis. The two "refute" points of identification which have been linked to the Gospels and the Shroud. It should be stressed that these authors did not work with the original skeletal materials as did Haas, but instead from photographs, casts, radiographs, and a study made 18 years ago. Such materials can be decieving, as well as memories or even notes made almost two decades earlier! Haas was prevented from continuing his work with the remains due to ill health. Although photographs were confused in his IEJ article, this should not be attributed to any inadequacy of identification by Haas, but possibly to a publishing error. The insistence by Zias and Sekeles that the indentation found on the right radius is not convincing as evidence that it was caused by a nail, since many such indentations are found on bones, is itself an unconvincing argument betraying the authors' lack of experience. If we argue merely from photographic evidence, in Plate 22:A, B, and C of Haas' IEJ article[11] a dent can be seen exactly where a nail would be driven, and at no other place can dents or scratches be found on the radius. Coincidence? Further, they state, "...two similar non-traumatic indentations were observed on the right fibula; neither are connected with the crucifixion." It is a pity that a photographic comparison was not made to back-up this interpretation. It is true that ancient skeletal material can sustain damage, but there are ways of determining whether those scratches, dents, and breaks were inflicted ante or post mortem as well as originating in the tomb. A dent as that on Yehohanan's right radius had to have been made either at his crucifixion or during the period his bones remained in the tomb before being placed in the ossuary. It is difficult to see how bones could be scratched after deposition in an ossuary. A dent is caused on fresh bone, while dry bone tends to exhibit roughened scratches or even minor splintering.

An argument against the ability of Zias and Sekeles to make valid observations of materials is found in the examination of the

references which they use by way of their own defense. In support for their theory that the wrists or arms were tied they say, "... the arms of the condemned were tied rather than nailed to the cross. There is ample literary and artistic evidence for the use of ropes rather than nails to secure the condemned to the cross.[21]"(12) Footnote 21 refers to Joseph Hewitt's article in the Harvard Theological Review. By reading that article, one immediately sees that Hewitt argues not against nailing the hands or wrists,(13) but rather against the use of nails in the feet. Zias and Sekeles have reversed Hewitt's argument as to which extremities were tied and which were nailed. If they had read the article, they would have seen that the author's thrust of argument is contained in the final paragraph:

> To sum up, there is astonishingly little evidence that the feet of a crucified person were ever pierced by nails. The strength of the tradition to that effect is due chiefly to the attempt to fulfill in detail a supposed Messianic prophecy,(14) assisted by the need of blood which theology felt in order that the sacrificial aspect of the Saviour's death might not be obscured or eliminated entirely.(15)

The Hewitt article is not based on archaeological evidence, but primarily on artistic materials of many centuries after the crucifixion of Christ, supplemented with only a few ancient authors. He refuses to accept the 3rd century graffito of Alexaminos, as a crucifixion scene, mostly on the grounds that the nails are not represented.(16) It should be remembered that graffiti is seldom detailed and never meant to be historically accurate. Furthermore, art forms, especially as they are removed in time from the actual event cannot be considered as true evidence, but as artistic impression. This has already been demonstrated by the Dura-Europos fresco of the tomb of Christ, which was painted only a little more than a century later.

It must also be remembered that the uncommon not the common was usually mentioned in ancient works as well as modern. The Gospels say simply that Christ was crucified without mentioning the use of nails (or ropes) until later in Luke 24:39, 40 and John 20:27 when Christ draws the attention of His disciples to His "hands" (wrists) and feet to prove His identity. "The obscure inscription on the ossuary that indicates that Yehohanan was posthumously nicknamed 'the one hanged with knees apart'"(17) causes one to wonder why he was

given such a nickname. Was this name given to everyone who was crucified? Or, was it because, by having his feet straddling the cross, Yehohanan was crucified in an unusual manner memorialized by the inscription?

HEIGHT The height of the man depicted on the Shroud has been given a variety of measurments ranging from 162cm (5'3½") to 187cm (6'1½").[18] A compilation of heights from skeletal remains can be made from archaeological reports, to list a few:

	Male	Female
Abba Cave (Jerusalem)[19]	154cm (5'½") to 156cm (5'1½")	148cm (4'10½")
En Gedi[20]	165cm (5'6")	
French Hill(Jerusalem)[21]	167cm (5'6")	146cm (4'9½")
Galilee(Rome, Peter?)[22]	170cm (5'7")	
Givᶜat ha-Mivtar(Jerusalem)[23]	167cm (5'6")	157cm (5'2")
Jericho[24]	160cm (5'3")	
Naḥal Ḥever[25]	162cm (5'3¼")	
Tell Ḥesbân(Jordan)[26]	152cm (5') to 167cm (5'6")	

This gives rough averages between 152cm (5') to 170cm (5'7") for men and 146cm (4'9½") to 157cm (5'2") for women, for typical Palestinian heights during the Roman period (63 BC to AD 70/135). While these could not prove the height of Christ, they provide an archaeological framework on which to build.

POSITION AT INTERMENT The position of the man on the Shroud, the wrists crossed over the pelvis, has been called into question as being either impossible to hold or against Jewish practice.[27] These objections may be easily answered. Rigor mortis and the tying of the wrists not only make the position easy to hold, but the only position possible. A parallel to the wrists being tied (as well as feet) can be found in John 11:44, where upon his resurrection, both the hands and feet of Lazarus had to be untied. Archaeological evidence for this points to Qumrân, a settlement of the same period, where a skeleton maintaining the same position was found.[28]

The lack of evidence which archaeologists ridicule is due to their own inefficiency in reporting, as in B. Ravani's excavation report of a tomb at Ḥuqoq[29] where stick-figures were used to repre-

sent skeletons, which could hardly be considered adequate in any sense. Total disintegration or a jumbled mass of bones found in secondary burials can also be blamed. With the example of the female skeleton of Tomb 7 at Qumrân, the precedent has been set. Generally in archaeology, one instance is enough to establish a parallel.

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② For such restriction see: N. Haas, "Anthropological Observations on the Skeletal Remains from Givᶜat ha-Mivtar," IEJ, Vol. 20, Nos. 1-2 (1970), pp. 38-59; Vassilios Tzaferis, "Crucifixion: The Archaeological Evidence," BAR, Vol. XI, No. 1 (January-February, 1985), p. 50; Patricia Smith, "The Human Skeletal Remains from the Abba Cave," IEJ, Vol. 27, Nos. 2-3 (1977), p. 121, footnote 3; Joseph Zias and Eliezer Sekeles, "The Crucified Man from Givᶜat ha-Mivtar: A Reappraisal," IEJ, Vol. 35, No. 1 (1985), p. 22.

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⑤ Smith, IEJ, pp. 121-124.

⑥ Rachel Hachlili and Ann Killebrew, "Jewish Funerary Customs During the Second Temple Period, in the Light of the Excavations at the Jericho Necropolis," PEQ, 115 (1983), p. 119.

⑦ Hachlili and Killebrew, PEQ, p. 115.

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⑩ Zias and Sekeles, IEJ, pp. 22-27.

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⑫ Zias and Sekeles, IEJ, p. 26.

⑬ Hewitt, Harvard, pp. 29-45. For references to the nailing of the hands, see Book VI:545 of M. Annaeus Lucanus, De Bello Civili, Trans. J.D. Duff, Loeb (1962), "She purloins the nails that pierced the

hands;" and Lucian, Prometheus, Trans. A.M. Harmon, Loeb (1915), "Come, hold out your right hand. Secure it, Hephaestus, and nail it up, and bring your hammer down with a will. Give me the other hand too." The dates of both these authors make them superb witnesses to the practice of crucifixion: Lucan, AD 39-65 and Lucian AD 125-180.

(14) Reference to the prophecy of Psalm 21:17, "They pierced may hands and my feet."

(15) Hewitt, Harvard, p. 45. Hewitt expresses the belief of some that crucifixion was somewhat bloodless, even with the use of nails it was insufficient to fulfill the amount needed for the remission of sins. He maintains that "...the artist responds only very slowly to the theologian's need of blood....Probably the flagellation would cause more bloodshed than ordinary crucifixion, and sometimes the crucified figure is made to show the bloody effect of the scourge. But there seems to have been a feeling that bloodshed caused by what was after all only a preliminary of crucifixion could not take the place of life-blood....The only way, then, of securing the necessary blood was to derive it from the hands and feet." p. 39. For further discussion of how the victim was secured to the cross see: Josef Blinzler, The Trial of Jesus (Cork, Ireland, 1959) or the German version: Der Prozess Jesu (Regensburg, 1969). One only need view the Shroud to see that more than enough blood was shed.

(16) Hewitt, Harvard, p. 30, footnote 1. Hewitt has also misunderstood the history of crucifixion by attributing its origins to the Egyptians on p. 40, for which he gives no references for such a statement. This was also picked-up in a blanket statement by Zias and Sekeles, IEJ, p. 26. For a brief history see Tzaferis, BAR, p. 48.

(17) Yigael Yadin's interpretation cited by Zias and Sekeles, "The Crucified Man from Giv^{c}at ha-Mivtar - A Reappraisal," BA, (September, 1985), p. 191.

(18) Dorothy Crispino, "The Height of Christ: According to the Holy Shroud," Studies in Sindonology, No. 1 (July, 1979).

(19) Smith, IEJ, p. 123.

(20) B. Arensburg and P. Smith, "Appendix: The Jewish Population of

Jericho: 100 BC-70 AD," PEQ, 115 (1983), pp. 133-136.

(21) B. Arensburg and Y. Rak, "Skeletal Remains of an Ancient Jewish Population from French Hill, Jerusalem," BASOR, No. 219 (October, 1975), pp. 69-71.

(22) Walsh, Peter, p. 107.

(23) Haas, IEJ, p. 55; Arensburg and Rak, BASOR, p. 71. On page 35 of Kenneth E. Stevenson and Gary R. Habermas, Verdict on the Shroud (Servant Books, Ann Arbor, Michigan, 1981), the height of adult Jewish males in a 1st century grave site is listed as 5'10" for the mean. Their footnote 4 refers to Haas' IEJ article on Givᶜat ha-Mivtar. There is no way one can arrive at the height 5'10" from any of the metric values given by Haas.

(24) Arensburg and Smith, PEQ, p. 134.

(25) Arensburg and Rak, BASOR, p. 71.

(26) John J. Davis, "Heshbon 1976: Areas F and K," AUSS, Vol. 16, No. 1 (1978), p. 138.

(27) Hachlili and Killebrew, PEQ, p. 115.

(28) Roland de Vaux, OP, "Fouille au Khirbet Qumran," RB, Vol. 60 (1953), pp. 83-106. See especially p. 102 and Plate V.

(29) B. Ravani, "Rock-cut Tombs at Ḥuqoq: The Excavations," 'Atiqot, Vol. 3 (1961), Figure 1, Tomb 1.

CHAPTER 7

COINS ON THE EYES

A wave of dismay hit Shroud researchers when Rachel Hachlili and Ann Killebrew published an article in a 1983 issue of the Biblical Archaeologist,(1) which stated: "The confusion surrounding the coin-on-eye custom and Jewish burial customs of the Second Temple Period first appears in an article by Eric Jumper, John Jackson, and Kenneth Stevenson,Jr. ..." What Hachlili and Killebrew fail to say is that impetus to that confusion was given by Hachlili in the Biblical Archaeology Review(2) where she states: "Two additional coins of Herod Agrippa I (41-44 AD) were found in a skull. The coins originally must have been placed on the eyes of the deceased...." But Hachlili and Killebrew misquote that article by saying in BA, "It was stated that they had apparently been placed on the deceased as payment to Charon...." No mention is ever made of the fact that Hachlili originally agreed with the coin-on-eye theory.

The point is missed entirely by arguing how prevalent the custom was. It does not seem to be a matter of how prevalent, but that the custom did exist, and apparently in two forms, coins on the eyes and a coin in the mouth, to which two indisputable finds can be listed: The burial at ᶜEn Boqeq on the western edge of the Dead Sea,(3) where two silver denarii of Hadrian (ca. AD 133) were found placed over the eye orbits with a coin of the Bar-Kokhba Revolt nearby; and two silver denarii of Trajan (ca. AD 117) found, one each between the teeth of two individuals in tombs of the Nabataean necropolis of Mampsis in the Negev.(4) Hachlili and Killebrew then state that while "the practice of placing coins in the mouth does sporadically appear, more rarely among Jews," "...it is highly doubtful that the interred at ᶜEn Boqeq was a Jew."(5) Actually, no evidence was cited as to why they concluded that the interred at ᶜEn Boqeq was not a Jew. One wonders how they would have used the Bar-Kokhba coin if they wanted a Jewish identification. They have listed only one indisputable site where coins were placed in the mouth. It seems that a precedent has been set for both forms of the custom. All the other sites mentioned cannot be used either way, in fact, they say, "None of the coins from the survey of tombs given above was found in any kind of context that would suggest that they

were part of the burial custom.[6] Therefore, on what grounds can it be stated that there is more evidence for coins in the mouth? Jericho?

The most misleading and ill reported evidence concerning coins and their placement comes from Hachlili and Killebrew at Jericho, "The discovery of several coins inside skulls may indicate that coins had been placed in the mouth of the deceased."[7] And in BA, "...two coins stuck together were found in the second skull. The latter occurance indicates that they had been placed together, that is, in the mouth, as opposed to separately, one over each eye."[8] If one looks at a skull, it is immediately evident that there is no way a coin placed in the mouth can drop into the brain cavity of the skull.

Figure 105.

During the degeneration of the soft tissues in the mouth, a coin would fall through the mandible into the neck and possibly upper chest region (Figure 105). The soft tissues of the mouth would decay much faster than the bone, therefore a coin in the mouth would never have a chance to fall into the skull. The foramen magnum is the only hole in the skull near the mouth, but due to the fact that it is where the spinal column connects with the skull, it is highly unlikely that area would degenerate faster than the area of the mandible, providing an access point to the skull. If coins had been found "stuck together" in the skull, it does not necessarily mean that they were originally placed together. Any archaeologist or conservator should know that two corroded metal objects which are allowed to touch for a prolonged period under normal humidity will

continue to corrode and fuse together. If a coin had been placed over each eye and through decay of the body, the thin, soft bones of the eye orbits degenerated sufficiently, the coins could drop through into the skull cavity, touch and continue to corrode together.

The skull in question was part of a large mass of bones in a secondary burial. It would be almost impossible to discern the original placement of the coins, since the skull was disturbed long before by being moved to the location observed at the time of the find. Several possibilities exist for a solution: An examination of the skull to determine if the orbits are intact, if they are not, the coins could have dropped through into the skull. Corroding metal often leaves stain on bone or other objects with which it comes in contact for a prolonged period. Bronze objects, in this case coins, will leave a green stain, silver purple or black, iron reddish-brown, and gold green to blue, since almost all ancient gold was alloyed with copper. Any trace of green stain on the orbits, mandible, upper ribs or vertebrae could indicate the original placement of the coins. If this too fails, the placement of the coins within the skull would rest entirely on the person who moved the bones to the site of secondary burial.

There are too many coins in Jewish tombs to keep saying "intrusive," that archaeological term used generally in frustration when something neither fits nor can be explained. If the two coins from Hachlili's find were originally in the mouth, the number "two" seems strange and is unattested anywhere else in Palestine, the only actual evidence being one in the mouth as found at Mampsis. In fact, even numbers of coins become dominant in finds. The cemetery at Tell Ḥesbân (biblical Heshbon):[9] Tomb F.18 (Early Roman kokhim type) six Nabataean coins from Aretas IV (9 BC to AD 40);[10] Tomb G.10 (Early Roman rolling-stone tomb of the kokhim type) one Nabataean coin of Rabbel II (AD 71-106);[11] Tomb F.12 (Late Roman shaft tomb) four unreadable lepton-like Roman coins;[12] Tomb F.16 (Late Roman shaft tomb) four coins in the east grave and two in the west grave;[13] Tomb F.5 (Byzantine arcosolia tomb) two coins one Late Roman, the other Byzantine.[14] Besides the two finds of one coin each between the teeth at Mampsis, in another tomb at the same location there

were two layers of burials, several coins of about AD 300 in the first layer and one coin of Rabbel II in the second.[15] And, of course, ᶜEn Boqeq where two of three coins were found over the eyes.

Of the seven tombs just described, six contain even numbers of coins. Is it reasonable to suggest that even numbers of coins might represent placement on the eyes, while single or uneven might indicate a coin in the mouth? Nabataeans definitely used coins on the body in burial custom as exhibited at Mampsis where there was a mixing of Jewish and Nabataean customs. Borrowing existed between different cultures and it must be recognized that what was prescribed in Jewish law was the ideal, but was not always followed. Heshbon (modern Tell Ḥesbân) was a frontier town where Herod settled his vetran soldiers to protect Jerusalem from marauding tribes of western Arabia.[16] Of the nineteen coins found with burials, seven are Nabataean and all of these seven were found in the kokhim type tomb known to be a Jewish style of construction.

Cremation was a Roman practice[17] used especially in the outlying provinces to prevent mutilation of the body by hostile occupied peoples and would hardly allow a coin or coins in the burial. This would rule out Roman identification for the man of ᶜEn Boqeq. Cremation was never practiced by the Jews of the Roman period, who believed that the body must remain somewhat intact. This was assured by the practice of secondary burials composed of either large bone piles in one section of a tomb or by the use of ossuaries. Therefore the use of coins could not have come to the Jews through the Romans.

The Mishnah, Shabbath 23:5, states:

> They may not close a corpse's eyes on the Sabbath; nor may they do so on a weekday at the moment when the soul is departing; and he that closes the eyes [of the dying man] at the moment when the soul is departing, such a one is a shedder of blood.

Clearly, the closing of the eyes was considered important, so much so that the time of their closing was regulated, neither on the Sabbath, nor in anticipation of death.

In rebuttal to William Meacham's[18] attempt to refute Hachlili and Killebrew,[19] Dr. L.Y. Rahmani[20] adds a new variation to the prolonged argument over coin placement, that of Jewish revulsion at the

use of anything Roman.

> Is it plausible that two strictly observant and pious Jews, both members of the Sanhedrin - Joseph of Arimathea and the Pharisee Nicodemus...- together with Christ's own relatives and disciples, would include in a pious burial, undertaken 'in the manner of the Jews'...an obscure foreign practice?...would those good Jews cover the eyes of a Jew who had just been put to death by the Romans in a most cruel manner with coins minted by the Roman procurator who had ordered this execution, coins carrying the name of the emperor...?

To which we might answer, in a time of severe grief and in great haste, would they have bothered to look at the coins or care? What other coins would they use?

At death a series of reactions take place in the body in specific order, the first is that the eyes will flatten and sink.(21) There could be no hint of the eye areas as seen on the Shroud, let alone by the VP8 image analyzer, if something had not been placed over the eyes. The fact that Father Filas(22) was able to identify letters, even a misspelled word which is found on a rare coin of Pontius Pilate, when coupled with ESSJ's April testing hints strongly at the correctness of his identification.

ESSJ's Image Test 4 (see Chapter 2) produced evidence which may lead to the final solution of this debate. A coin of Pontius Pilate (Figure 54) was placed on the right eye of the manikin at the beginning of the test, leaving the left eye free as a control for comparative purposes. When the cloth was removed from the manikin, a smug was clearly noted over the coin's location (Figures 55 and 56). When analyzed the following was observed, while there was no discernable image detail from the coin due to a leak in the manikin's forehead which flooded the face, the fibers of the linen were affected in the same manner as body image fibers, with the exception that, rather than the misty yellow of body image, the coin area fibers are a green-gray and a metallic residue is present. The green-gray coloration of the fibers is no doubt due to the previous oxidation of the coin from age. It is reasonable to assume that the acid-alkaline reaction, speeded by heat would affect the soft metal of a bronze coin as drastically as the linen fibers.

It is absolutely essential that the eye areas(23) of the Shroud of Turin be examined for either or both metallic residue and a different image coloration than the body. If discernable, the one

time presence of coins on the eyes would be irrefutable and as valuable in dating the Shroud as Carbon 14. Some have objected that C14 would only provide a date for the cloth and not the image. The transference onto cloth of coins from the eyes would date the image process itself.

Another objection has been that the coin "image" as seen on the Shroud does not match the size of an actual coin. It may be noted that linen is apt to change structurally with age, humidity or lack of it, and the manner in which the cloth is displayed. Dr. Alan Whanger pointed out a 1mm distortion in the face which may have been caused by the vertical exposition of the Shroud in 1973.(24)

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CHAPTER 8

THE TEXTILE

If the Shroud were to be found in situ in a tomb, how would archaeologists analyze it? Unfortunately, because of the climatic conditions of Palestine, only fragments of cloth are usually found. Then too, the decomposition of the body, since bodies were not embalmed during the Roman period (or Second Temple period) among the Jews, would contribute to the deterioration of the cloth. An exception was the linen used as wrappers for scrolls and as covers for the jars in which the scrolls were stored in the Qumrân caves at the Dead Sea. The linen provided a Carbon 14 date which agreed with paleographic conclusions.(1) Bits and pieces of fabric adhere to corroded metal, bone, and leave impressions on ceramic.

In ancient Jericho, the imprint of cloth was found on several bones and a skull, while at En el-Ghuweir, pieces of cloth were discovered with skeletal remains, both of these finds suggest that the bodies had been wrapped in shrouds.(2) On the other hand, there is no archaeological evidence that the Jews ever wrapped bodies with bandage-like strips of linen in mummy fashion. This notion was begun by artists who misinterpreted the story of the raising of Lazarus (John 11:1-45), not realizing that the order to unbind or untie him was in reference only to his wrists and ankles.

Monsignor Giulio Ricci is very adept in his reconstruction of the position of Christ's body in rigor mortis and the manner in which the Shroud enfolded the body.(3) Not only has his treatment been confirmed by the image imprints on the Shroud, it is also matching evidence found in the tomb environment (see Chapter 2).

If one looks outside Palestine, a number of examples of linen along with varieties of other fabrics can be found. The oldest textile fragment comes from a burial in Level VI at Çatal Hüyük,(4) now in modern Turkey. The cloth proved to be linen produced by a yarn with a Z twist and was dated to ca. 6000 BC. It was found covering parts of a skull and other bones painted with red ochre. In Egypt, flax was the principle fiber, and until the Çatal Hüyük discovery, boasted of fabrics from the Fayûm which were dated to the fifth millenium BC.(5) Often times flax was used for warp and

wool for weft. Government control of linen in Egypt became rigid during the Roman period, especially to meet requisitions for tunics used by the imperial army.

Professor Gilbert Raes has identified cotton fibers spun into the flax yarn used to make the Shroud. John Tyrer has aptly pointed out the injunction in Deuteronomy 22:11 that wool and linen must not be mixed and that the Shroud falls well within this restriction.(6)

PRESERVATION The image on the Shroud of Turin will not last another 25 years,(7) however, another exposition and more scientific examination will greatly reduce that limit unless precautions are taken. This ominous warning comes from my comparative study of the Mylar tapes taken from the Shroud in 1978 with those of other linens, both ancient and modern, from Egypt, Ireland, Belgium, and Poland. Photographic comparisons between 1931 and 1978 show a loss of almost half the facial image. It must be understood that deterioration is not a process which follows a set rate, but rather accelerates toward a rapid end.

The image on the Shroud is caused by the dehydration of the cellulose of the flax fiber.(8) The fibers of the non-image areas are also dehydrating. When the level of dehydration in the non-image areas meets that of the image areas, the image will no longer be visible or retrievable. It is not a matter of fading as with dye colors, but rather a change within the cellulose itself.

A sample of Coptic linen(9) dating between the 3rd and 7th centuries AD illustrates, very well, problems of dehydration. Fibers of varying thickness and coloration reminicent of the Shroud show the deteriorative process of moisture loss. On the whole, fibers from the Coptic piece are slightly thicker than those of the Shroud indicating that the dehydration of the Shroud fibers is more advanced due to either greater age or the tremendous heat of the Cathedral fire in 1532.

The only way to control the dehydration of the fibers is to stabilize the Shroud's environment by controlling humidity, temperature, and the type of light which contacts the cloth. Leaving the Shroud rolled-up in storage is no answer and can be as harmful as the rigors of an exposition under certain conditions. Scientific examination can have its harmful effects as well, when what has mis-

takenly been considered as non-destructive testing is not properly recognized. The use of ultra violet light studies in 1969 and 1978 were deemed as non-destructive, because no immediate effects were observed, but it can be demonstrated clearly that specific forms of light attack the basic structure of fibers. Exposure to ultra violet light can affect flax fibers up to eight months later. The importance of the results of any test should be weighed against the long term damage which will be done. In other words, we must ask ourselves the questions, "How much are we willing to lose for a given bit of information?" "Should we preserve the integrity of the Shroud at all costs?" In my opinion, a balanced approach is best: Preserve it, test it, even Carbon date it, but by no means subject the image to a process which is not only total, but absolute. We cannot allow ourselves to take liberties which seem justifiable when truth will result. Such attitudes bring about unhealthy and careless practices which tend to multiply.

We know what the image is, we do not need to know how the image was produced in order to begin preservation. The Shroud's environment must be controlled. If it is not monitored, one day it will be removed from its silver case and only a blank piece of cloth will be seen, except for the blood stains and patches. It would,however, be the final, ultimate proof of its authenticity, since no forgery would react in such a manner.

CARBON DATING While we do not need to know the mechanics of the image process to begin preservation of the Shroud, it is essential to understand that process and the environmental history of the Shroud before attempting Carbon 14 dating.

Dr. William Meacham has built an excellent case,(10) not for the abandonment of Carbon dating, but rather for an exhaustive study to ensure the greatest accuracy possible from the test.

> The fact that significant discrepancies do often result from contamination in best sample materials from optimum archaeological conditions has major implications for C14 measurement of the Shroud. First and foremost is the abandonment of any notion that a radiocarbon age of whatever magnitude will settle for all time the question of authenticity. Second, an elaborate pretreatment and screening program should be conducted before the samples are measured. Third, the choice of sampling sites on the relic should be governed by considerations of possible contamination and by the desirability of

> measuring both typical and atypical samples. Finally, the result should be interpreted to the general public in the light of contamination and other uncertainties inherent in the radiocarbon dating method.(1)

I agree with Dr. Meacham in his assessment of the problems of Carbon dating the Shroud and also recommend that this form of testing be postponed until we know more clearly the true nature of the image and the environment in which that image was produced.

Our April testing shows that there are:

(1) Variables in the environment of the tomb which we did not expect.

(2) The condition of the body, in regard to the acids released in death in reaction to the alkaline environment with consequences in image formation is clearly not understood.

(3) Substances are now being discovered in the tomb which have contaminated the cloth, but the nature of those substances is not known.

(4) Additives at the time of burial have not been fully identified.

(5) There are various levels of contamination, such as calcium (limestone), which are now being recognized. (Chapter 2).

All of these factors would have a profound influence on Carbon dating. If we do not understand the processes involved in image formation, the nature, and substance of the contamination, then how could we expect the proper pretreatment to be made for Carbon dating? To begin with, experimentation on linens of known date which can be exposed to similar environmental conditions would be a basic requirement before testing the Shroud. The types of chemical reactions, as possibly responsible for image formation, can be seriously altered by time (such as 2000 years) and heat (as in the Cathedral fire of 1532).

Carbon 14 testing will and should come eventually, but only when we know enough to make all the allowances necessary for the greatest accuracy possible. Accusations against the Vatican, that there is a fear of exposing a forgery, while not valid, must someday be met. To forever avoid Carbon dating may be a serious error.

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CHAPTER 9

INTERPRETATION

Like the image on the Shroud of Turin, our Jerusalem Test Cloth 4 image has no definite lines, it blends almost imperceptibly into the background. The outside of Test Cloth 4 did not show the image areas as well as the side which came into contact with the body, only random areas of image penetrated to the other side. Does this make our mechanism for image formation invalid? If all the conditions listed for traumatic death, and in particular the tremendous heat of the body, are correct, then the process which resulted from our testing in the tomb will happen whenever those conditions are met and those effects should be present on the Shroud of Turin, no matter what other phenomenon may have occurred. It is an effect which must be dealt with.

While STURP asserted that the image on the Shroud only affects the topmost fibers of the threads,(1) I would question this on the grounds that identification of image fibers was made at 40x and 50x, when at least 100x with overexposure is needed as illustrated in Figures 49-52. Some of the STURP team members observed portions of the backside of the Shroud when areas were freed from the Holland cloth backing.(2) However, not enough areas could have been checked to state emphatically that the image does not penetrate. It must be remembered that the backing was sewn on with thousands of "invisible" stitches to prevent the Shroud cloth from being overstressed and wrinkled. Because a limited number of stitches were cut for the separation from the Holland cloth, Dr. Giovanni Riggi used an endoscope to "snake" through the maze of secured stitches in an attempt to view areas where image might have penetrated. This also cannot be considered as absolute proof, since image penetration can be random and those patches could have been missed.

If one studies the early portraits of Christ which various authors have linked to the Shroud image, such as Figures 108 and 109, it can be recognized immediately that the features in the early portraits match the reversed features in the photo negative, Figure 107, and not the actual cloth in Figure 106. Ian Wilson attributes this "...perhaps because of understanding of the re-

versing effect of an 'impression'.[3] It is my contention that these early artists were viewing the "other" side opposite that which we now observe. Artists, especially ancient, did not strive for accuracy, such as that required to mentally "flip" the image in his mind to compensate for a mirror or "impression" image. Artists even to this day paint portraits face-on as they view them and do not transpose features.

Figure 110.

Figure 110 is taken from Figure 108. Five points illustrate the reverse of the features of the cloth image, Figure 106, to the negative, Figure 107. The features, to name a few, include: (1) The strands of hair which are actually blood, (2) the enlarged left eyebrow, (3) the large wound to the right cheek, (4) the enlarged left nostril, and (5) the lengthened left side of the beard.

Could these artists have been viewing the other side? A side which was perhaps so damaged by the fire of 1532 that it was chosen as that to be covered by the Holland cloth? But if the image could be seen on both sides of the cloth before the 1532 fire, why don't we have some record of it? But then, why don't we know a great deal more about its history before 1532? If the image is a type of scorch, couldn't the temperature attained in the silver reliquary have altered that image scorch while adding others to the cloth?

In 1534, the Poor Clare nuns were given the task of mending the burned areas on the Shroud from the fire of 1532. Their report mentions several facts which may be interpreted as meaning that image could be seen on what we consider to be the non-image side. "And then Messire the Legate asked all the counts and barons who were present if it was the same Shroud that they had seen before, and they, after having diligently examined it, on one side and the other, testified that it was the same...."[4] Why was it necessary for them

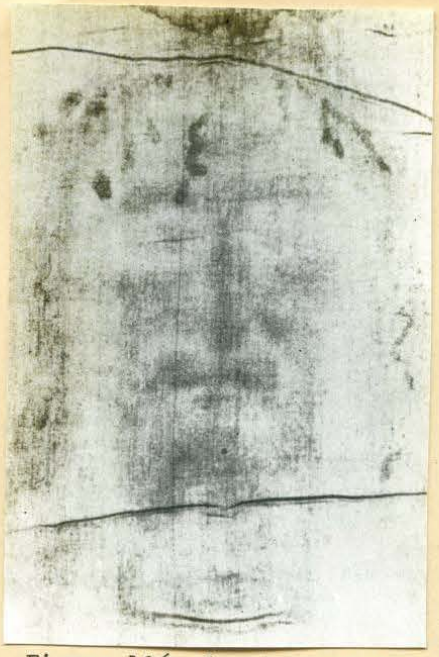

Figure 106, Courtesy of the Holy Shroud Guild ©.

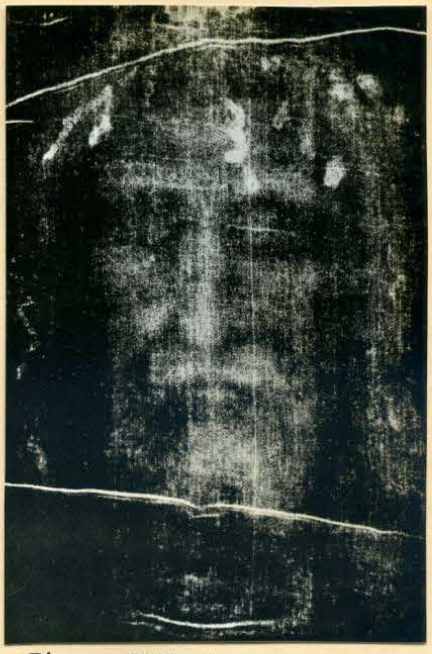

Figure 107, Courtesy of the Holy Shroud Guild ©.

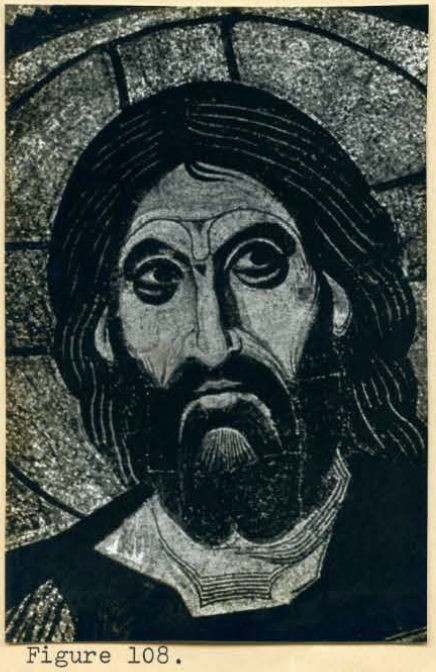

Figure 108.

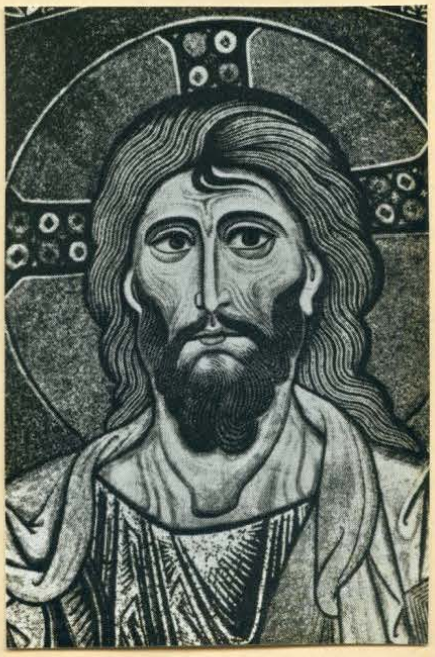

Figure 109.

to look at "the other side" for verification? Was there something about that side which would make it different? Also, "...on looking through the underside of the Shroud, when it was stretched on the Holland cloth or on the loom, we saw the wounds as if we had looked through a glass.'(5) Does this mean only the blood stains from the major wounds which soaked through the cloth, or all the wounds?

The Poor Clare nuns saw in detail that which we can only "see" today with high contrast photography. It may be that the gradual loss of the image(6) has so affected the backside that it is almost impossible to distinguish between image and non-image areas.

If the image did penetrate through the cloth, how do we know which side was in contact the body? Perhaps the best answer would be Father Francis Filas' coin on the eye theory. The coin "reads" correctly in the photo negative, Figure 107, which is comperable to the backside of the actual cloth. If one were to look at the facial image as viewed normally, Figure 106, the coin would give the mirror image from contact with the body, therefore, it is that side which actually touched the body.

If the image on the Shroud of Turin can be traced to a natural mechanism in the tomb, does that destroy evidence for the resurrection of Christ? In relation to the Gospels and the resurrection, the theory of natural image formation can be seen in the following context:

(1) The Gospels indicate that the burial of Christ was rushed. Bodies are usually cold when they are buried, but a body which is buried at a temperature of 115°F (that temperature required to form an image) shows extreme haste.

(2) The complaint by some that Christ was not really dead, but revived later by His disciples is not tenable, since no one can withstand a temperature of 115°F and live. Nor would that high of an acid condition (pH 6.60) be found on a living person.

(3) Only a human body and its characteristic cooling rate can maintain the types of temperatures required to produce an image on linen. Other materials, as suggested in the hot statue theory(7) will either hold heat too long and burn the cloth, or drop heat too quickly and produce nothing.

(4) The Shroud of Turin as observed in microscopic samples (the 1978

Mylar tapes) in accord with our image formation shows all the signs of death - it is truly a burial cloth. Chemicals found in abundance on the cloth in conjunction with heat and the types of acids known to be released in traumatic death clearly indicate that a corpse had been wrapped in the cloth. However, there are no signs of human decomposition.

(5) When death occurs with high body temperature, decomposition will set in rapidly.(8) If the body remained in the cloth for a period beyond three days, the decay of the body would have defaced the cloth and destroyed any image which might have formed. In the New Testament account of the raising of Lazarus, Christ arrived late and Lazarus had been buried four days. The people objected when Christ ordered the tomb to be opened, because the body had already begun to decay (John 11:17, 39). The body which had been wrapped in the Shroud of Turin ceased contact with that cloth in three days.

If the image can be formed naturally, why aren't more in existance? The climate of Palestine does not preserve ancient textiles. Bodies are generally buried cold and have been washed, thereby removing the acids from the skin surface and cooling the body, both essentials in image formation. Dead bodies usually stay in their shrouds and the body's decomposition not only defaces the cloth, but contributes to its deterioration.

Many people were crucified in 1st century Palestine, couldn't the man on the Shroud of Turin be someone else? Most victims of crucifixion were cast into earthen graves, rather than buried in limestone tombs and they were not permitted shrouds, especially cloth the quality of the Shroud of Turin. Even if they were allowed shrouds, the earthen fill of the grave would not have provided the correct environment, both in contact and substance, to form an image. While those crucified were not allowed to remain on the cross through the Sabbath, most hung in full view for days as a grim warning. This prolonged exposure would have allowed the body to cool, destroying the prime cause of image formation. Myrrh and aloes found on the Shroud would not be common in the burial of a criminal.

The marks of crucifixion on the man of the Shroud are highly significant for identification since: the man was crowned with thorns. This was a taunt due to the accusations brought against

Christ in a particular case. The savage scourging preceded this execution only because it was originally meant to appease the crowd to prevent His death, but it did not. The lance wound in the side of the chest was to test if death had occurred, not to induce it. Crucifixion, if ended prematurely was caused by the breaking of the legs which caused asphyxia, which made the lance thrust unnecessary. And lastly, none of the bones of the man on the Shroud have been broken. The circumstances of death were unusual, due to the trauma endured before crucifixion.

The objection could be raised that the disciples stole the body of Christ to give the appearance that He had risen. If they had, why did the cloth with its image remain? Why didn't they dispose of the cloth along with the body? Any attempts to use the Shroud among the Jews as evidence would have been a violation of the laws concerning objects which had come in contact with the dead. Such an abhorence would have been intolerable. Without the scientific knowledge we now possess about the image mechanism, the Shroud would have proved nothing. There is no record of its use or attempted use among the Jews by the disciples for either proof of Christ's existence or His resurrection. There could be no motive, nor possible use for the Shroud in the formation of a 1st century hoax.

There is no disagreement with the Gospels, nor is the belief in the resurrection of Christ harmed. The image is of death with the man's body in rigor mortis. If the image had been formed at the moment of resurrection, it should show a portrait of life rather than death. Perhaps it is a portrait He wanted us to remember - His death for us, because of His love for us. If the Shroud of Turin truly is the burial cloth of Christ, then we have been given an unparalleled privilege of looking upon God.

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CHAPTER 10

RECOMMENDATIONS

There is to date no aspect of the Shroud of Turin which does not fit the archaeological context of a 1st century AD Jewish burial cloth. The investigative strides which have been made by science must now be made by archaeology. Sindonology should and will someday take its rightful place among the various branches of archaeological research, but this will only happen when the Shroud is submitted to the same rigors as ceramic typology, paleography, stratigraphy, numismatics, and all the other fields which make-up the discipline of archaeology. New topics are readily accepted when they contribute new information and techniques. This report has only scratched the surface of what the Shroud has to offer. Anthropological and archaeological students should be encouraged to specialize in sindonology which would demand that ancient tombs not be subjected to the hap-hazzards of a salvage operation performed too quickly, but to the same methodical exactness of the stratigraphic excavation of the Tell.

Only when the Shroud is placed in its proper archaeological context will it no longer be considered a medieval Church relic. While it will happily remain safely in Turin, a shift in the awarness of its Jerusalem origins would enable the Shroud to realize its greatest potential as witness and its absolute authenticity.

It is my fervent hope that the following recommendations will be given serious consideration by all who will perform hands-on examination of the Shroud in the future, by researchers, and by students who wish to become sindonologists.

RECOMMENDATIONS FOR HANDS-ON EXAMINATION OF THE SHROUD IN TURIN:

(1) Examination of the eye areas of the image on the Shroud to detect a difference in image coloration as opposed to the body and/or the presence of metallic residue, either of which might at last resolve the issue as to the previous placement of coins on the eyes (Chapter 7).

(2) Study, in depth, concentrations of calcium as to quantity, particle size, and distribution over all surfaces of the Shroud, to detect areas of greatest contact relevant to positioning the body in burial (Chapter 3).

(3) Ascertain quantity and distribution of myrrh, aloes, and other possible burial "spices," and any effects which they might have had on image areas (Chapter 5).

(4) Scan completely the depth penetration of image on both frontal and dorsal areas for the possible existence of image on the "outside" of the Shroud, since magnifications of 40x are not great enough to determine fully fibers affected by image, especially without back-lighting (Chapters 2 and 9).

(5) Potassium has been found on the Shroud, it has also been found on other burial cloths and in the limestone taken from grave sites. Is it in the image area only or covering the entire surface of the Shroud, and does it play a role in the image process?

(6) Greater study of particles on the fibers: their coloration (red, black, yellow, colorless), their distribution, quantity, patterns, and relation to image and existence in non-image areas (Chapter 1).

(7) The need for a comprehensive catalogue listing all the contaminants which have been found on the Shroud with accompanying research notes. For example, listings including such items as:

Aloes
Calcium carbonate
Crystals
Fibers: red silk
cotton
yellow
dark blue
light blue
green
brown
Fur
Hair
Insects
Iron
Myrrh
Paint
Particles: red
black
yellow
colorless
Pollen
Potassium
Strontium
Wax
etc.

Each item to be followed by:

1) Location on Shroud (frontal or dorsal with specific orientations).
2) Observed by whom?
3) Possible origin?
4) Interpretation.
5) Effects (on: image process, preservation, etc.).
6) Parallels (with other burial cloths, with tombs, etc.).

RECOMMENDATIONS FOR FURTHER INVESTIGATIONS OF ARCHAEOLOGICAL TOPICS RELATED TO THE SHROUD:

(1) Microanalysis of newly discovered and previously excavated tombs in Palestine/TransJordan by sticky-tape sampling of all surfaces (such as: walls, ceilings, floors, benches, pits, bone repositories, doorways, lamp niches, frescos, etc.) and burial furnishings (such as: ossuaries, all associated objects, wooden coffins, textile fragments, etc.) since there appears to be more involved than the presence of myrrh, aloes, and pollen. (Chapter 5).

(2) Build a comparative sticky-tape collection of ancient linens for microanalysis to explain contaminants and processes on and in the Shroud, for example, dehydration rates, origins of foreign matter and their possible use in burial customs, or the role they play in image formation. (Chapter 8).

(3) Greater examination of human skeletal reports from Palestine for more evidence concerning crucifixion (Chapter 6).

(4) Extended studies concerning coins related to burials in Palestine (Chapter 7).

(5) Greater analysis of ancient cloth discovered in tombs, other types of burials, and occupation sites (Chapter 8).

(6) Skeletal analysis to determine physical characteristics, such as height (Chapter 6).

(7) Further research into the style of Christ's tomb (Chapter 4).

(8) Investigation of the use of burial "spices" as found in excavations and literary sources and their relation to burial customs (Chapter 5).

RECOMMENDATIONS FOR FURTHER TESTING IN A TOMB ENVIRONMENT, SPECIFICALLY IN ISRAEL:

(1) Examine more closely the effects of humidity variations on image formation.

(2) Establish an accurate body cooling rate under various conditions in the tomb.

(3) Perform comprehensive sampling of limestone, both in Jerusalem and around the country.

(4) Perform comprehensive sampling of pollen.

(5) Make a prolonged study of temperature, humidity, and limestone moisture in and outside the tomb, using the single chambered (sealed)

tomb as well as the big, multi-chambered type.

(6) Perform more image tests under a greater variety of conditions.

(7) Perform more testing, under varying conditions, for the saturation rates of different types of linen in the tomb.

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