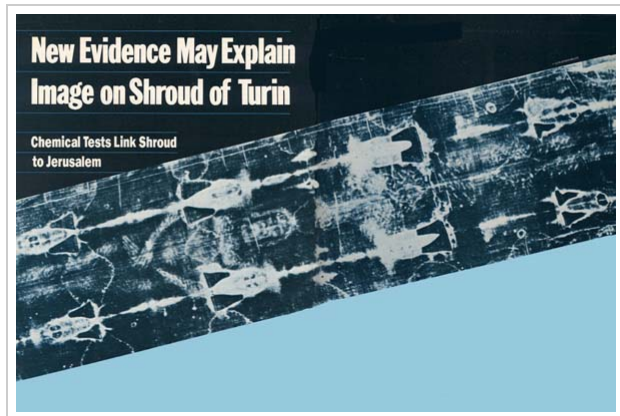
New Evidence May Explain Image on Shroud of Turin

Chemical tests link shroud to Jerusalem

By Joseph A. Kohlbeck, Eugenia L. Nitowski



Even the skeptics have been unable to explain how the image on the Shroud of Turin was created.

Moreover, modern science deepens, rather than allays, the mystery. If we knew less, we could assume more; we could suppose a host of easy answers—like painting. But the arsenals of modern science have done nothing but destroy the easy answers: Easy answers will not do. And still there is no explanation. The mystery remains.

We believe we may have now found a naturalistic explanation for the formation of the image of the crucified man on the Shroud of Turin. This explanation strongly suggests that the image was produced by the body of a crucified man in first-century Judea—and that this body had the characteristics reflected on the shroud.

We say "strongly suggests" because we cannot exclude all other possibilities. In scientific terms, we admittedly have not "proved" our case, but the evidence peculiarly points to this place and this time. Until evidence of another likely possibility is shown, we must rely on the evidence we have found.

Nor do we claim that we have scientifically proved that the shroud once covered the crucified body of Jesus. Science can never exclude the possibility that someday someone will come up with another, different and more satisfactory explanation for the formation of the shroud's image. Moreover, we cannot prove that there were no other crucified bodies in first-century Judea that produced this image.

With these reservations, however, we shall set forth our new evidence. Before doing so, we should explain how we came to undertake the investigation that led us to our conclusions.

On one thing, everyone can agree. We are a most unlikely team. Joseph Kohlbeck is an optical crystallographer. He works for the Hercules Aerospace Division, the company that produces the Trident, Poseidon and Pershing missiles. Eugenia Nitowski is an archaeologist who has now taken the vows of a Carmelite nun. We have written this article together and have chosen to identify our individual contributions.

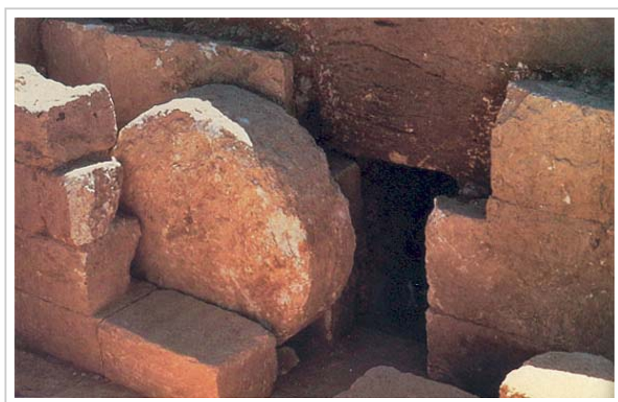
Kohlbeck: I became involved with the Shroud of Turin when an old friend of mine and a member of the STURP[a] team, Ray Rogers, asked me to take some quality photomicrographs and to microscopically examine some shroud fibers. Rogers had removed the fibers with Mylar tape during STURP's 1978 examination of the shroud. I had access to optical equipment at Hercules that was not available to Rogers at the Los Alamos National Scientific Laboratory where he worked as a chemist.

This naturally led me to consider some of the broader questions concerning the shroud. At a church I attended, I heard about a novice nun who had an archaeological background in Israel and Jordan. Maybe she could answer some of the questions that were forming in my mind about the environment in which the image was created, assuming that the image was produced by natural means in first-century Judea. So I contacted her.

Nitowski: As it happened, I was the ideal person for Kohlbeck's queries. My special interest was in tombs of that period. I had served on the excavation staff at Tell Hesban in Jordan where, in 1971, I had excavated the first rolling-stone tomb ever to be found east of the Jordan River. This led to my study of tombs in Israel as well as in Jordan in an effort to "reconstruct" the tomb of Jesus, based on archaeological evidence.

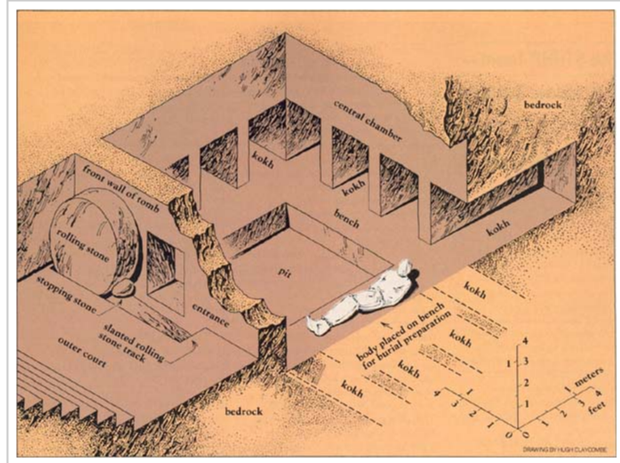
Kohlbeck: In the course of my work with the materials Rogers gave me, I began to focus on particles of calcium carbonate on the fiber samples. I wondered whether there was anything in the tomb environments of first-century Judea that might account for their presence.

Nitowski: I have studied 61 rolling-stone tombs in Palestine/Transjordan, dating from the Early Roman through Byzantine periods (63 B.C. to 640 A.D.). I have studied many other tombs of this period without rolling stones. Based on this study, I have reconstructed the most likely architectural features of Jesus' tomb. It is clear both from the Gospel evidence (*Matthew 27:60*; *Mark 16:3*, *5*; *Luke 23:53*, *24:3*) and the archaeological evidence that Jesus' tomb was located in a burial cave. There was probably a courtyard outside the cave. The entrance to the cave was quite small, approximately two feet by three feet, allowing access by only one person at a time. In Jesus' burial cave, as we learn from the Gospels (*Mark 15:46*, *16:3*, *4*; *Luke 24:2*) this entrance was controlled by a rolling stone consisting of a large, round stone disc set on edge. Two kinds of rolling-stone tracks have been found: those with slanted tracks, which provide automatic closure if unattended, and level tracks, which on the other hand, enable movement of the stone by one person. In other caves, the entrance was controlled by a square slab, or by a swinging door that could be locked. The closure was never meant to be permanent because of the continual need for reuse: Inside the cave was provision for a number of burials.



Directly inside the entrance to the cave was a central chamber. Two or three steps led down from the entrance threshold. The ceiling was always high enough so that a person in the central pit could stand upright. The central pit creates benches, or ledges, that line three or four of the walls of the central chamber. Additional rooms or chambers were sometimes cut off of the central chamber.

The bodies were interred in what are called in Hebrew *kokhim* (singular, *kokh*), or loculi—horizontal burial niches cut into the wall, each long enough to contain a single body. Each *kokh* was approximately two feet wide, three feet high and six feet long. In cave chambers that have not been frequently used, we often find only the beginnings of *kokhim* carved into the walls, hinting at the tomb's final intended form. The size of the chamber was dependent on the number of planned *kokhim*.



The benches in the central chamber were wide enough to hold a body for washing and anointing before being placed in a *kokh*.

The many Jerusalem examples of these cave tombs with *kokhim* leave little doubt as to what they looked like.

As members of the burial party entered the cave, which because of the small entrance admitted only one person at a time, they carried, along with the body, oil lamps, washing vessels, spices and ointments, as well as small household objects that may have been meaningful to the deceased, all of which were left in the tomb because of the laws of ritual cleanliness. Visually preparation of the body took place on one of the benches in the central chamber.(1) Then the body was placed head first into the *kokh*. The *kokh* was often sealed with a stone slab.

One other point is critical for our purposes—these tombs were cut into soft, moist limestone outcroppings.

In studying these tombs, I noticed that this soft, moist limestone would continually rub off on my clothing, especially as I entered the cave tomb during excavations.

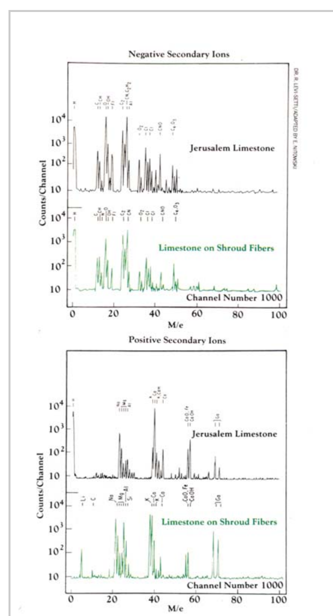
Kohlbeck: No investigation of the shroud had ever suggested examining samples of the limestone from a tomb in the vicinity of Jesus' burial place. Could this limestone, which is calcium carbonate, be the source of the unexplained calcium carbonate particles I found on the shroud's fibers? We obtained samples of limestone from inside tombs in the general vicinity of Jerusalem. We then subjected thin sections of this limestone to microscopic analysis.

This particular limestone was primarily travertine aragonite deposited from springs, rather than the more common calcite. Calcite and aragonite differ in their crystalline structure—calcite being rhombohedral and aragonite orthorhombic. Aragonite is less common than calcite. Aragonite is formed under a much narrower range of conditions than calcite.(2)

In addition to the aragonite, our Jerusalem samples also contained small quantities of iron and strontium but no lead.(3)

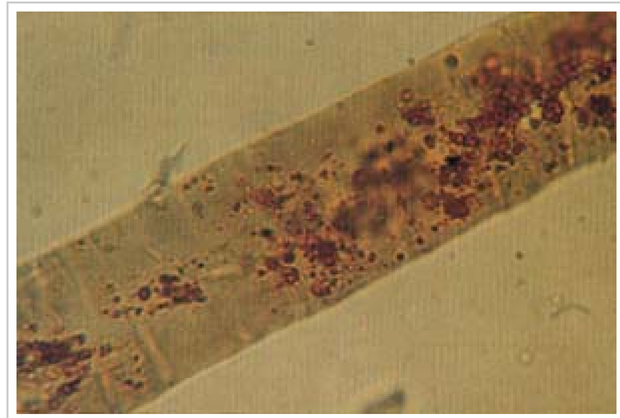
We then examined a calcium sample from the shroud taken from the area known as the “bloody foot”(4) because this showed a larger concentration of calcium carbonate than other areas. This calcium carbonate turned out to be aragonite, not the more common calcite—and exhibited small amounts of strontium and iron.(5)

Further analysis was conducted by Dr. Ricardo Levi-Setti,(6) 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; these graphs revealed that the samples were an unusually close match, except for the minute pieces of flax that could not be separated from the shroud’s calcium and caused a slight organic variation.

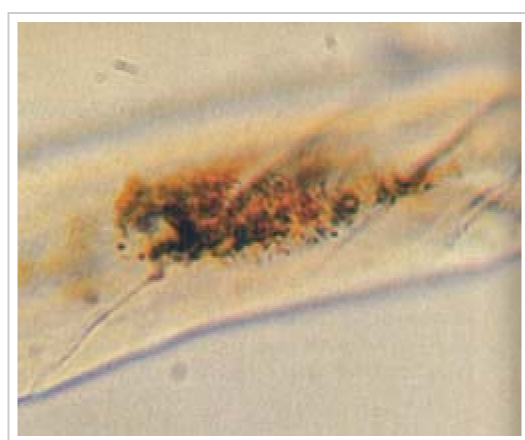


Of course, this doesn’t prove that the aragonite on the shroud came from Jerusalem, but this could be a reasonable explanation. Nevertheless, aragonite with these traces can no doubt be found elsewhere in the world as well as in Jerusalem. On the other hand, those who claim the shroud is a 14th-century forgery need to explain how the aragonite got there.(b)

Kohlbeck: I would now like to discuss the red particles attached to some of the fibers of cloth in our samples. During the 1978 STURP tests, approximately 30 Mylar or sticky-tape samples were taken from areas on and around both the front and back images on the shroud.(7) The aragonite samples from the shroud previously discussed came from these samples.[8] On the sticky tapes taken from the "blood" areas are red particles. These red particles are not found in other areas of the shroud. The red particles vary from clusters of about ten microns to single particles which range from two microns to about seven tenths of a micron.



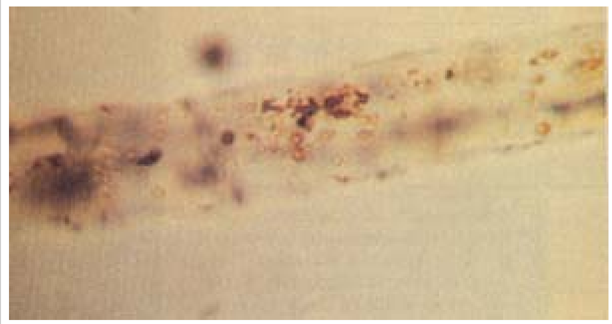
I soon realized that the images of the fibers, and thus of the red particles, would be much improved if the Mylar tape could be removed. After receiving Dr. Rogers's permission, I separated some of the fibers taken from the lance-wound area to observe them further without interference from the Mylar tape.[9] I ended up with five samples of fibers with red particles attached. I then mounted these samples in two different kinds of immersion media, two in a silicone oil stable to over 300° C and three in a Type A 1.515 Cargille oil. This would heat two of the samples and make it easier to photograph all of them. After photographing, I further processed two of the samples, from which I learned little.[10] I then stored the three other samples I had immersed in Cargille oil. Two and a half months later, I took out these samples to look at them again. Most of the red particles had changed from red to black; a yellow color was now exuding from the black; further examination of the black particles showed what appeared to be a cluster of cell-like structures where there was once a cluster of red particles. Those particles that had previously measured one or two microns in diameter now appeared to have nuclei. These apparent nuclei continued to change. Over time, I continued to observe these particles with nuclei and gradually they became colorless and difficult to see.



Several conclusions can be drawn from these observations. The red particles are organic rather than inorganic. Absolute identification cannot be made, but most likely these particles are blood-related, as reported by John Heller and Alan Adler.[11] Heller and Adler earlier reported the presence of blood using chemical tests. The observations here are supportive of their analysis.

Some time ago, Dr. Walter McCrone of the McCrone Research Institute declared that the red particles he had observed adhering to the flax fibers on the shroud were not blood, but rather iron oxide,[12] as could be found in red paint, hinting at the work of an artist or forger. McCrone then proceeded to demonstrate a non-brush stroke technique by finger painting iron oxide onto cloth. We do not question that some strong iron oxide contaminant can be found on the sticky-tape samples,[13] but the red particles we examined were shown to be organic, not inorganic. Accordingly, the red particles that changed cannot be iron oxide.

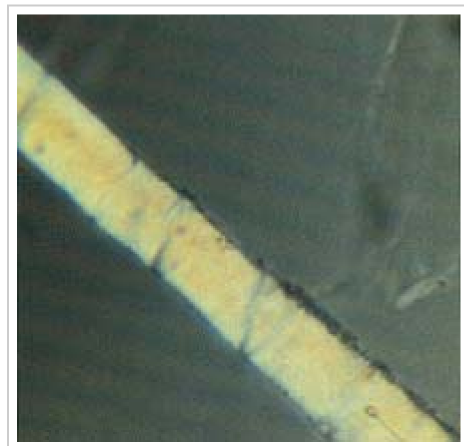
There are other conclusions to be drawn from our observations. The change in the color of the red particles over time suggests—for the first time—that the shroud is a dynamic rather than a static system. Thus there is a continuous state of change, albeit at a very slow rate.



With this possibility in mind, we reexamined blood area fibers from other untreated samples. They showed numerous colorless or slightly yellow particles that may have originally been red and undergone a change similar to the changes noted in our study. Particles in all colors were found on these untreated shroud samples, ranging from colorless to black, with red predominating. In short, some of the now colorless, black and yellow particles may originally have been blood. By contrast iron oxide particles show an even red coloration throughout and are not affected by age. They cannot explain the blood-appearing substance that can be seen on the shroud.

Nitowski: A further observation: I prepared a massive catalogue of all the significant items to be seen on the sticky tapes taken by the STURP team. This showed that there are proportionally not enough particle-covered fibers to produce the image. In short, the image on the shroud must have been created by a change within the cellulose of the flax, not by the particles attached to the fibers. In this, we agree with the STURP team.

Kohlbeck and Nitowski: Our further examination of limestone samples from Jerusalem suggested an explanation as to how the image might have been formed by transformation of the fibers. Our Jerusalem limestone samples were found to be mildly alkaline, probably because of small amounts of calcium oxide or hydroxide present in the aragonite. This would give a mildly alkaline solution when combined with water. We made a paste of the Jerusalem limestone with distilled water and then applied this paste to new linen fibers, slightly rubbing the paste into the fibers. The slightly alkaline limestone (aragonite) attacked the outer skin of the fibers, producing a yellowish color very similar to the color of image fibers of the shroud. The small amounts of iron in the Jerusalem limestone carried with the water are responsible for the yellowish color. The process by which this slightly alkaline limestone attacks the outer skin of the fibers is known as mercerization. Mercerization only occurs in a mildly alkaline condition.



Jerusalem cave tombs are almost always wet and damp. The limestone is soft and moist. Anyone working in these tombs soon finds his or her clothing half covered with this mildly alkaline limestone as inevitably one brushes against limestone. This occurs especially when entering through the small two-by-three-foot entrances.

This process of mercerization would be speeded up by heat. This consideration led Nitowski back to a consideration of the physiology of crucifixion.

Little attention has previously been given to the heat generated by a body that has undergone hematidrosis (bloody sweat), scourging and crucifixion. Dr. Pierre Barbet recorded observations made at Dachau, the World War II German concentration camp near Munich. Prisoners at Dachau were hung by their hands and their 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.”[14]

In a study of heatstroke victims made in Israel between 1956 and 1966,[15] a number of interesting and highly explanatory correlations to crucifixion can be made. Thirty-six male patients, between the ages of 17 and 24 were clinically observed after the onset of the illness. Contrary to what was commonly thought, 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 exertion, lack of sleep, lack of fluid intake, and profuse sweating. The most prominent findings in the autopsy reports of the fatal cases were: acidosis of the blood, disturbances in blood coagulation that 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 increased the metabolic heat load.

The parallels between the victims at Dachau and the heatstroke victims studied in Israel and the trauma Jesus endured before and during crucifixion are staggering. They may provide a solution for the onslaught of Jesus' sudden death during crucifixion when added to Dr. Barbet's conclusion that death in crucifixion results from asphyxiation.[16] From the agony, beginning Thursday evening, to his death on the cross Friday afternoon, Jesus suffered severe dehydration from sweating, blood loss and lack of fluid intake, which was compounded by lack of sleep and extreme physical exertion. If these conditions overloaded his body's ability to dissipate the high temperature thereby produced, and heatstroke was induced, a new list of agonies can be added to those already known.

In any event, a great deal of body heat is produced by crucifixion. This body heat in combination with the mildly alkaline content of the Jerusalem limestone environment of the shroud might well have resulted in a mercerization process that attacked the outer skin of the fibers of the shroud, leaving the yellowish-tone color of the image—the same color found when the Jerusalem limestone paste was applied to new linen fibers.

In short, the extreme body heat produced by crucifixion may have resulted in a mercerization process that produced the image on the shroud by interaction with the mildly alkaline aragonite containing traces of iron.

If the image on the shroud indeed occurred in this way, the process explains another little-noticed anomaly in the image on the shroud.

The front and back images on the shroud differ greatly in clarity and definition. The back image is a faint blur, with the main constituent being blood. Because of the condition of the dorsal (back) image, no three-dimensional image of the back is possible. By contrast, a three-dimensional image can be produced with the front.(17) This difference has received little in-depth discussion and is usually not even mentioned, except by those whose aim is to prove the shroud a forgery.(18)

This difference in front and back images, however, is explained by the proposed process of image formation suggested above. Assume that the crucified body inside the shroud was laid on the cold stone bench in the tomb. If the shrouded, crucified body was placed on a limestone tomb bench for further preparation, the back of the body would have been in contact with the cold, wet limestone, resulting in cooling and increased moisture. Cooling would have slowed or stopped the image-forming process. The front of the body, on the other hand, would have remained warm longer, allowing the formation of the image through mercerization on the moist, slightly alkaline cloth. Analogous to this is the action exhibited by warm or cold developer in photographic printing: the warmer the developer, the faster and darker the print appears; the colder the developer, the slower and lighter the print appears; and, if the developer is very cold, the print will not develop at all. If our theory is correct, this explains why the image on the back developed hardly at all, while the image on the front is far clearer.

We can perhaps carry this explanation even further. On the dorsal (back) image there appear to be alternating strips of light and dark areas within the image. Perhaps this can be explained by the fact that the body, being in rigor mortis, did not evenly touch the cold limestone bench. Where the body touched, the image process was slowed, or stopped, making the area appear lighter, while the darker image areas are those which have not been in contact with the limestone bench.

We have begun to perform some experimental work to test these theories, but the results are by no means conclusive and much work remains to be done. In one experiment, we filled a small, hollow, three-foot tall medical manikin[19] with water heated to a temperature between 110° and 115° F. Water was used as the medium to be heated since the human body is 98 percent water. We found that the manikin cooled at roughly the same rate as a body. We heated the water to this temperature because crucifixion could easily raise the body temperature to 108° F. Moreover, at death, a condition known as postmortem caloricity (or postmortem fever) elevates the body's temperature five or six degrees above that maintained at death.

The manikin was then wrapped in pure, untreated Belgian linen that had been lightly dusted with calcium carbonate. Acetic acid was added to normal saline to produce an acidic sweat solution. Because both perspiration and blood become acidic during severe trauma, this set up conditions for an acid alkaline reaction that would be compounded by heat. The shrouded body was placed in a totally dark basement with a temperature ranging between 62° and 65° F and a relative humidity from 58 to 66 percent. A water mist was sprayed over the shrouded manikin which was then left for a period of thirty and a half hours.

Upon subsequent examination of the cloth, image was obtained in the areas of the manikin's body that retained heat the longest, namely the chest and back.[20] This experiment is suggestive only. Much experimental work remains to be done.

Whether or not we can prove that the heat of the body and mercerization will cause an image like that on the shroud, this is surely a naturally produced possibility that must be considered by all who are studying this puzzling relic.

The STURP Team—Hi-Tech Problem Solvers Tackle the Shroud's Mysteries

By Wendy Miller

The Shroud of Turin—a nearly 2,000-year-old relic or an exquisitely clever forgery? The mystery has recently attracted a small army of detectives that would make any police department crime lab jealous. Organized as STURP (the Shroud of Turin Research Project), these "detectives"—state-of-the-art specialists in an array of scientific disciplines—rendezvoused at the Royal Palace of Turin in October, 1978. Their mission: to don white gloves, spread the 14-foot-long linen cloth on a special, rotating test table, and probe the shroud (or photos of it) with X-rays, spectroscopes, a VP-8 Image Analyzer, ultraviolet fluorescence, macrophotography, phonomicrography and other space-age tools and techniques.

The genesis of STURP dates to 1974, when two U.S. Air Force scientists, John Jackson and Eric Jumper, intrigued by some 1931 photographs of the shroud, decided to process the photos with a VP-8 Image analyzer. A kind of fancy computer, the analyzer takes satellite photos of the moon and planets and turns them into three-dimensional topographic reliefs.

To the scientists' shock, the analyzer produced a relatively undistorted, three-dimensional image of the man of the shroud. This transformation would have been impossible if the shroud image were a standard two-dimensional painting.

Other scientists heard about Jackson and Jumper's work. In March 1977, a meeting was arranged in Albuquerque, New Mexico, and the project was underway. Soon the scientists got permission to conduct nondestructive tests on the shroud at the close of the public exhibition scheduled for the fall of 1978.

However, approval did not come through for one critical test, carbon dating, which might have fixed the age of the cloth within a range of 120 years. The Archbishop of Turin, although in favor of carbon dating in principle, was not convinced that the test could be done with enough credibility.[c]

But the STURP team was undaunted. For five days, more than 30 American scientists worked with Italian colleagues and a Swiss criminologist on a precisely choreographed 24-hour-a-day schedule. They photographed the shroud more than 500 times, vacuumed it, pressed it with sticky tape, subjected it to X-rays, ultraviolet radiation and infrared light.

What were the experts able to measure, detect or discover? Ultraviolet and X-ray fluorescence produced clues to the shroud's chemical makeup. Since whole blood does not fluoresce, some STURP scientists believe that the stains around "wound" images on the shroud are serum, the thin liquid that separates from blood. X-rays of the stains also revealed a level of iron compatible with blood.

The vacuum and the strips of tape seized bits of fiber that could be scrutinized back home in the lab. Most scientists who analyzed the red stains on the cloth have now concluded that the stains are human blood, but two team members dissent. Microscopist Walter C. McCrone contends that the stains are iron-oxide paint applied, he suggests, by someone who wanted to enhance the image on the shroud. Most of the team members, however, agree that the shroud image shows no signs of brush marks; in other words, the image was not painted on.

Samuel Pellicori, an optical physicist and spectroscopist, says that the color of the supposed bloodstains "is startlingly reminiscent of recent blood and not at all what one would expect after a minimum of 600 years." But chemist Ray Rogers says that the shroud may have been washed in soapwart, a plant used in antiquity as a detergent, which has the property of maintaining blood cells.

Obviously, the team has not reached a consensus. Each scientist, in his or her own lab or office, has continued working since returning home, but as some problems are solved, new ones are revealed.

Shroud of Turin—What It Is and Where It's Been

By Wendy Miller

A skilled weaver crafted the Shroud of Turin, spinning bleached linen and then looming the thread in a herringbone twill pattern. The shroud measures 14.25 feet long and 3.58 feet wide. Sometime after it was woven, but before it appeared in northeastern France in the 14th century, a 3.5-inch-wide linen strip of matching weave was sewn onto the left edge of the cloth.

Faint images appear on the cloth—images of the front and back of an unclothed man, about 5 feet 7 inches tall, with long hair and a beard. If the images were produced by a body, that body would have been placed, lying on its back, on the bottom half of the cloth; then the cloth would have been stretched over the top of the body.

The man whose images appear on the cloth seems to have suffered numerous wounds, some of them leaving what look like bloodstains on the cloth. There is a large wound in his left side and another in his right wrist; there are shoulder abrasions, puncture marks in the head and scores of small straight wounds covering the body from the neck down.

But even more striking than the clear signs of a tortuous death is the great detail in the image of the man's face. Lips, eyelids, nostrils are all astonishingly clear, and the composite visage arrestingly lifelike and undistorted. The hands, too, appear clearly, while other areas, like the chest and toes, are poorly defined, and some areas, like the genitals, are invisible.

This haunting image has for centuries drawn people to venerate the cloth. In 1357, the shroud made its first reliably recorded public appearance, in Lirey, France, but its existence as a far older relic has been argued. British journalist Ian Wilson asserts that the shroud is the same cloth as the *mandylion*, or face cloth, of Edessa (modern Urfa, in Turkey), which allegedly displayed the facial image of Jesus. First reported in the sixth century, the *mandylion* was brought to Constantinople in the tenth century. A knight-historian of the Fourth Crusade relates that in a Constantinople church in the early 13th century he viewed a shroud, "which stood up straight every Friday, so that the figure of Our Lord could be plainly seen there."

With the Crusades came an increase in the long-standing practice of selling Christian religious relics. By the 14th century in Europe, this trade had reached a fever pitch. When the owners of the shroud displayed the cloth in France in 1357, they widely promoted the event, as a pilgrim's medallion from the exhibit now on display at the Musée de Cluny in Paris attests. On the medallion appear the coats of arms of the owners, Geoffrey de Charny and his wife Jeanne de Vergy, as well as the first known depiction of the double-image shroud.

In a statement on the 1357 display, a local bishop denounced the shroud as a fraud. The bishop said that the shroud was "cunningly painted, the truth being attested by the artist who had painted it."

But the shroud continued to be exhibited, both outdoors and in, always drawing large crowds. The Roman Catholic authorities, however, were not as enthusiastic as the general public. When the shroud was displayed in 1389, a successor of the bishop who had denounced it in 1357 wrote a letter of protest to the pope. A former lawyer, the bishop wrote a stinging attack on the canons of the church of Lirey; he argued that the church leaders had:

> "falsely and deceitfully, being consumed with the passion of avarice and not from any motive of devotion but only of gain, procured for their church a certain cloth cunningly painted, upon which by clever sleight of hand was depicted the twofold image of one man, that is to say the back and front, they falsely declaring and pretending that this was the actual Shroud in which our Saviour Jesus Christ was enfolded in the tomb."

Although the pope was not sufficiently swayed by the bishop to withdraw the shroud from public display, he did enact some restrictions on each future appearance: Pomp and ceremony were not allowed, and a priest would announce to all "in a loud and intelligible voice, without any trickery, that the aforesaid form or representation is not the true burial cloth of Our Lord Jesus Christ but only a kind of painting or picture made as a form or representation of the burial cloth."

In 1453 de Charny's granddaughter Marguerite gave the shroud to the Duke of Savoy. The duke built a special church for the shroud at the family castle in Chambery, where it lay folded in a silver reliquary chest. A near tragedy befell the cloth in 1532 when the church caught on fire. But the shroud was saved; a counselor to the duke and two priests risked their lives to rescue the burning chest. They drowned the flames with water, but when the chest had cooled enough to be opened, they discovered that molten silver had dropped on the cloth, burning through all the folds.

Since 1532, the most prominent marks on the shroud have been the results of the fire water stains, scorch lines along the folds, and linen patches that a group of nuns spent two years sewing onto the cloth.

The duke moved the capital of Savoy from Chambery in southeastern France to Turin in northwest Italy. In 1578 he transported the shroud there, and except for a pause during World War II, it has remained safely in Turin since.

Pilgrims, including the archbishop of Milan, were still drawn to the shroud. But the papal office continued an official reserve, never affirming the cloth's authenticity. In 1670, a papal congregation granted an indulgence to Turin pilgrims who prayed before the shroud, but "not for venerating the cloth as the true shroud of Christ but rather for meditating on the Passion [of Jesus]."

Perhaps because of the conservative attitude of the Roman Catholic authorities, public displays dwindled only seven in the 19th century, once in 1931 and for six weeks in 1978. This most recent exposition, commemorating the shroud's arrival in Turin 400 years before, drew an astonishing number of people. More than three million believers, skeptics and the simply curious crowded into the Royal Chapel of the Cathedral of St. John. They had been enticed by findings, widely reported in news media around the world, of European scientists who had inspected the shroud in 1969 and 1973. These scientists had, in turn, become intrigued by the shroud because of predecessors' discoveries.

In 1898, photographer Secondo Pia captured the image of the shroud on glass-plate negatives and made an astounding discovery—the image on the plate was a positive, not a negative. This meant that the image on the cloth was a negative.

How could a negative image have been produced hundreds of years before the invention of photography? Suddenly scientists became attracted to the shroud's mysteries and began experiments. Experts in zoology, botany, even a surgeon, studied the photographs and conducted tests.

One expert, Swiss criminologist and botanist Max Frei, claims he found pollen spores on the shroud that come from desert plants native to the Dead Sea area and other parts of ancient Palestine—evidence, says Frei, of the shroud's authenticity.

By the 1978 exposition, some 30 American scientists physicists, chemists, computer specialists, biophysicists, spectroscopists and experts in photomicroscopy—had organized the Shroud of Turin Research Project (STURP) to travel to Turin and study the shroud round the clock for five days after the public exposition ended. The work of this American group has resulted in several books and numerous articles, but an official report has not appeared.

Meanwhile, the shroud again lies folded and wrapped in red silk, unconfirmed as a true relic, but revered by millions.

Joseph A. Kohlbeck, a specialist in optical crystallographic techniques, is a Resident Scientist at Hercules Aerospace, in Magna, Utah. In his work on such defense weapons as the Polaris, Minuteman, Trident and MX missiles, Kohlbeck has developed a unique optical microscopic and crystallographic laboratory at Hercules.

All work ›

Eugenia L. Nitowski, now Sister Damian, of the Discalced Carmelite order, has excavated at Tell Hesban in Jordan and has made extensive studies of ancient tombs in Jordan and Israel.

All work ›

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Footnotes

1.

Shroud of Turin Research Project.

2.

Scientists continue to compare the chemical composition of shroud limestone and Jerusalem limestone. Their hope is that they will detect rare trace elements on both samples that will clearly distinguish them from aragonite samples elsewhere in the world. To date—no such “marker” has been found.

Endnotes

1.

Body preparation could be carried out in the home as well as at the tomb, but especially in the case of criminals, interment was immediate and preparation was in the tomb.

2.

Aragonite will form from calcite solutions at 80°–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 deposits particularly when the iron is present as siderite (iron carbonate).

3.

These substances were detected by x-ray fluorescence. Lead was detected by the STURP team on the shroud fibers and by Joseph Kohlbeck in Jerusalem limestone samples. Dr. Levi-Setti, however, did not detect lead when he compared the mass spectra of Jerusalem limestone and shroud fibers (see graphs).

4.

Mylar tape sample JAB.

5.

Little could be done to examine the few small particles microscopically in the environment of the Mylar tape used to lift the sample because the tape had crystalline properties which interfered with obtaining optical information from the particles. Thus the risk was taken to recover these few crystals and remount them in a 1.680nD Cargille immersion oil. The intermediate or b [beta] index of aragonite is 1.680, and a match at specific orientations would be a good indication of the possibility of aragonite. In one orientation there was a match for the 1.680 index oil. An interference figure at 1250× having a small 2V angle estimated 18–20 optically negative was observed. 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 and the aragonite had 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.

6.

Ricardo Levi-Setti, G. Crow and Y. L. Wang, "Progress in High Resolution Scanning Ion Microscopy and Secondary Ion Mass Spectrometry Imaging Microanalysis," *Scanning Electron Microscopy*, 1985, 11, pp. 535–552.

7.

A popular account of the STURP tests can be found in Kenneth E. Stevenson and Gary R. Habermas, *Verdict on the Shroud* (Ann Arbor, MI: Servant Books, 1981) or a more technical version in Larry S. Schwalbe and Ray N. Rogers, "Physics and Chemistry of the Shroud of Turin: A Summary of the 1978 Investigation," *Analytica Chemica Acta*, 135 (1982), pp. 349. Lists of the tapes and their identifications can be found in John H.

Heller and Alan D. Adler, "A Chemical Investigation of the Shroud of Turin," *Canadian Society of Forensic Science Journal*, 14/3 (1981), pp. 97–98.

8.

The tape samples were given to Joseph Kohlbeck in October of 1982 by Dr. Ray Rogers of the Los Alamos National Laboratory for the purpose of obtaining quality photomicrographs. Following this work, Rogers granted permission to pursue some additional investigative work.

9.

The fibers and adhesive were separated by carefully washing the adhesive from a small tape sample taken from the lance-wound area with reagent grade toluene. The reddish particles were unaffected by the toluene wash and continued to adhere to the fibers. There were, however, a few clusters that broke off from the fibers during handling.

10.

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 with heat.

11.

Heller and Adler, "Blood on the Shroud of Turin," *Applied Optics*, 19/16 (1980), pp. 2742–2744.

12.

Walter C. McCrone and C. Skirius, "Light Microscopical Study of the Turin Shroud," *Microscope*, 28/3 (1980), p. 105.

13.

There are a number of possible explanations for the rare paint contaminant, if that is what the iron oxide is. Quite often an inscription concerning the dead was written in red paint above the niche (or *kokh*) where the body was to be laid. 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. In addition, the tomb caves were often decorated with frescoes of various colors. Any or all of these could have found their way onto the shroud in microscopic amounts. In addition, medieval copies of the shroud were laid on top of the shroud to produce "touch relics"; these could also have been sources of some types of paint contamination.

14.

Pierre Barbet, *A Doctor at Calvary* (New York: Doubleday, 1963), p. 208. Another example of increased body temperature in a cool environment that closely parallels Barbet's account is that found in Fredrick Zugibe, *The Cross and the Shroud* (New Jersey: McDonagh, 1981). On p. 108, he describes the 70° 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."

15.

S. Shibolet, R. Coll, T. Gilat and E. Sohar, "Heatstroke: Its Clinical Picture and Mechanism in 36 Cases," *Quarterly Journal of Medicine*, New Series XXX, 144 (Oct. 1967), pp. 525–547.

16.

See Dr. Zugibe's study cited in endnote 15, pp. 89–90, and his letter to the editor in Queries & Comments, **BAR** 11:03.

17.

A conversation with Dr. John Jackson on September 2, 1985 confirmed that there is indeed an inequality in the frontal and dorsal images. With a sophisticated instrument called a VP-8 Image Analyzer, scientists have been able to produce a three-dimensional image from photos of the front of the shroud. However, they cannot produce a three-dimensional image of the dorsal side that equals that of the front.

18.

Robert A. Wild, "The Shroud of Turin: Probably the Work of a 14th-Century Artist or Forger," **BAR** 10:02. Raymond E. Brown, "Observations on the Shroud of Turin," *Biblical*

Theology Bulletin, 14/4 (Oct. 1984), p. 147.

19.

The manikin is submersible, so body heat was added by simply heating water and filling the body. The manikin was provided through the courtesy of Simulaides, Inc., Woodstock, NY.

20.

Incidentally, the experiment appears to destroy effectively the so-called hot-statue theory (see discussion of various scorch theories in Schwalbe and Rogers, "Physics and Chemistry of the Shroud," pp. 25–28. According to these theories, the image on the shroud was produced by an artistic scorching process from a heated statue. It is true that, if tenable, this process would produce an image that does not contain directional strokes like a painting. But in light of our experiment, the hot-statue theory is not tenable to explain the observed character of the shroud's image—the dehydration of the cellulose. All of the materials used in the production of statues, when heated, will either hold that heat too long and unevenly burn areas of the cloth, or dissipate heat too quickly and produce nothing. Only the heat of a human body and the characteristic rate at which that body's temperature eventually lowers to meet its environment can produce an image of a quality approaching that exhibited by the Shroud of Turin. The image process lasts only as long as the body maintains a temperature above its surroundings.