By Larry Adams, Editor

A Mummy Mystery Revealed

Thousands of images, powerful computers, advanced algorithms, a reality center — the mystery of the mummy is revealed after five decades, and two thousand years.

Once blocked by opaque bandages, the child mummy's resin-soaked head, visible through a 'cut' section of the cartonnage, can be more closely examined by researchers.

This 3-D model of the mummy distinctly shows the difference between bandages and cartonnage through color.

These detailed viewings of the mummy's skeletal remains, as seen through a cut section of the cartonnage around her head and feet, demonstrate the impact of the technology, providing never-before-seen images of the resin in the chest cavity and four canopic packages of her intestines, liver, stomach and lungs placed between her legs.

Photos: Silicon Graphics Inc., Stanford and Volume Graphics GmbH

- More than 60,000 images were taken to produce the 3-D visualization rendering of the child mummy.
- A visualization system running ray-tracing software was able to take the more than 82 GB of data, and process it to create the 3-D rendering.
- A reality center featuring 25-foot screens allowed researchers to virtually unwrap the mummy to make a diagnosis.

First, the skull virtually unwraps. The cartonnage and the ancient wrappings, crisscrossed with the jagged outlines of the child's hair that mixed with the resin during the mummification process, are stripped away. Moving into the skull, then turning into the chest cavity, riding through it, ribs overhead. Down to the misaligned pelvis, which was once thought to be a key to the child's death, and the short leg bones to the feet — gnarled toes splayed out like a fan of white digits.

Skerit, the child mummy, dates back more than two thousand years. She — for it turns out that the mummy is a she — was a mystery to the curators of the Rosicrucian Egyptian Museum (San Jose, CA) who named her. Who was this mummy child? Was it a boy or a girl? And why was the head cocked at such an odd angle, the hands crossed over the chest?

X-rays taken in the 1950s provided some answers. But, as it turns out, the answers were partially wrong, partially incomplete. They did not shed light on the mummy's sex and only a guess as to the age. It did not determine if the child was disabled and how badly and could not give a cause of death.

"The X-rays didn't tell us much, because all X-rays show us is the outline of the bone," says Lisa Schwappach-Shirriff, curator at the Rosicrucian Egyptian Museum. "The child (was) completely invisible to us. All we see is a mask and wrappings, but when you look at the interactive models, you actually see the inside."

It took modern science to unlock these mysteries, to determine that the child was not killed nefariously or by some tragic accident. In X-rays, her hips are displaced, which researchers at the time thought was proof that she had died as

Photo: Stanford Radiology

The Mummy on C-Arm Axiom Scanner at Stanford. Cross sectional slices as small as 200 microns were captured with this system.

the result of some accident. Instead, the child most likely died from an intestinal illness or disease.

A FANTASTIC VOYAGE

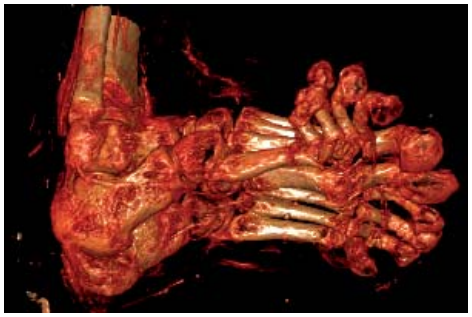
Traveling through a 3-D visualization rendering, doctors, dentists and other researchers made a thorough diagnosis of the child. The trip was made without having to remove the cartonnage mask covered with gilt that rests over the face and chest of the child, or disturb the resin-soaked wrappings that cover the small figure.

Sitting before 25-foot screens at Silicon Graphics (SGI, Mountain View, CA), seeing inside the encased child mummy, they explore the remains, entering the skull and the chest. They examine bone and teeth, hair and amulets, linen wrappings and resin.

They judge the age to be four-and-a-half to six years old, based on many things — not the least of which is the embedded adult teeth that had not yet pushed through the gums. They judge it to be a female. They decide that there were no signs of injury and that she had most likely died of one of many illnesses that struck Egyptian children at that time.

"In just looking at an image, you can construct a potential pattern of cause of death," says James Gamble, MD and professor of orthopedic surgery at Stanford. "There is absolutely no indication of dietary deficiency. The cortex of all these bones is beautiful and pristine, which leaves us then down to infection as being the most likely cause of death."

Photo: Silicon Graphics Inc., Stanford, and Volume Graphics GmbH



Resin-soaked toes of child mummy. This image show dislocated toes during mummification.

A MYSTERY SOLVED

The Rosicrucian Egyptian Museum has been in possession of the mummy since the 1950s, but knew little about the small figure. As the museum approached its 75th anniversary, curators were determined to learn more. They reached out to Stanford University School of Medicine, which houses one of the world's most advanced scanners and to SGI, which has experience in 3-D renderings of ancient mummies.

"If you take images all around an object and you use a mathematical algorithm to reconstruct, then you can actually get a slice through the object, and then you can see things much more clearly," says Rebecca Fahrig, Ph.D., of the Department of Radiology at Stanford. "You can see the bone; you can see the soft tissue, the fat and the skin, instead of having everything oriented on top of each other."

On May 6, Skerit was carted from the Rosicrucian Egyptian Museum to the Stanford University School of Medicine. Three scanners took 60,052 images of the mummy in one day.

For the project, radiologists used the AXIOM scanner from Siemens (Malvern, PA) — one of five in the world — which generated 2-D slices as thin as 200 microns as it moved over the mummy, capturing images as it rotated.

Other images were gathered using a Siemens Sensation 16 CT scanner, and digital radiography images from Eklin Medical Systems (Sunnyvale, CA). Microscopic samples were analyzed using mass spectroscopy, infrared spectroscopy and Raman spectroscopy.

In all, more than 82 gigabytes (GB) of data was captured. It would take months to analyze it all.

By comparison, a 3-D visualization of King Tutankhamen's mummy had slices at 750 micron slices. The data generated from the Skerit mummy was about 35 times that of King Tut.

The images were processed on Silicon Graphics' Prism Visualization platform with Intel Itanium 2 processors running VGL ray tracing software from Volume Graphics GmbH (Heidelberg, Germany). Ray tracing software traces the path taken by a ray of light through a scene, such as the mummy, and calculates reflection, refraction or absorption of the ray whenever it interacts with the scene.

The mummy was revealed at SGI's Reality Center Theater, equipped with a curved, 25-foot, 3840x1024-pixel projection screen and a Silicon Graphics Prism visualization system powered by 24 Itanium 2 processors and 30 GB of main memory.

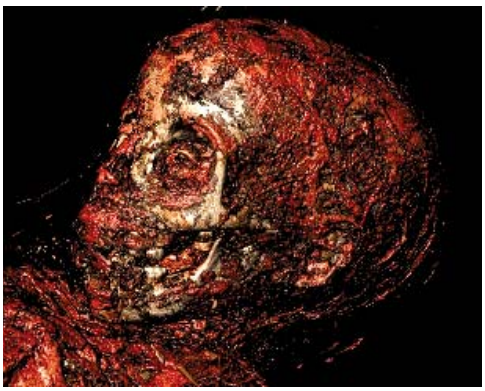


Photo: Silicon Graphics Inc., Stanford and Volume Graphics GmbH

Resin-soaked body of child mummy shows ears and hair.

The renderings answered the museum's questions, including why the head was tilted downward. As it turns out, the cartonnage was made too small and the child mummy had to be crammed into the space.

"Real anatomy exists in three dimensions, so any time you can view anatomical data in 3-D, you'll have much more accurate picture of the subject," says Paul Brown, DDS, of the Stanford-NASA National Biocomputation Center, who viewed the images and helped answer questions about the mummy through a study of the teeth. "Even multiple 2-D CT slices can never allow you to understand a subject's dental condition as quickly or as accurately as a quality 3-D visualization." AI

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