Microscopical Investigation of Selected Raes Threads From the Shroud of Turin

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Introduction

Shroud scholars were stunned in 1988 when a medieval date of origin was assigned to the Shroud by three laboratories performing Carbon 14 dating analysis on a small segment of cloth taken from the edge of the Shroud. Years of study had produced reams of data both analytical and circumstantial that indicated the Shroud was nearer twenty centuries old rather than medieval.

Some investigators tried to rebut the C14 dating by pointing out the problems with this method. All biological materials do not absorb C14 at the same rate and there was no absolute proof that the amount of C14 in the atmosphere had remained invariant before the industrial revolution. Ogden (1) pointed out these discrepancies in 1977, but since that time calibration methods have been developed which improve the accuracy of the dating process.

Since then the most fruitful area of investigation to dispute the dating process has involved the composition of the sample chosen for C14 analysis. This sample was removed from the edge of the cloth adjacent to a sample removed by Professor Gilbert Raes of the Ghent Institute of Textile Technology in 1973 (2). Raes found that the samples contained cotton within the linen threads. Only traces of cotton are found on the Shroud.

Rogers (3) has done extensive microscopical and chemical analysis of Shroud fibers. Differences in the amount of vanillin and lignin between Shroud fibers and Raes

fibers indicate that the main part of the Shroud is older than the sample removed for C14 analysis. He also found a coating or encrustation on the Raes fibers that is not on the Shroud fibers. The coating is primarily gum Arabic with a mordant and traces of madder root dye.

Optical Microscopy

The author, as a microscopist, has had an opportunity to examine some of the Raes threads. **Figure 1** shows a weft thread, R7, at an original magnification of 28X. The thread has a yellow-brown coating with the exception of indented regions which are white. These indented regions are at the intersection with the warp thread. The weave was tight enough that the application of a relatively viscous gum/mordant/dye solution did not penetrate the intersection of the threads. This would appear to be obvious evidence of a medieval artisan's attempt to dye a newly added repair region of fabric to match the aged appearance of the remainder of the Shroud. **Figure 2** shows the same thread at 56X magnification. The coating and encrustations can be seen on individual fibers.

The warp threads in the cloth are more rigid and do not show indentations as prominent as the weft, but they do show variations in the surface coating from weft intersections and disturbance of the thread during handling. Ultraviolet light at a wave length of 254 nM reveals these variations in Raes thread R14 as seen in **Figure 3**. The original magnification was 14X.

The cotton fibers found by previous investigators are evident during examination of thread R14 in a stereomicroscope at 100X magnification. Cotton can be identified by its tape-like structure and frequent sharp bends. The cotton fiber in **Figure 4** is observed by phase contrast transmission microscopy in a mounting fluid n=1.515 and slightly crossed polars. This cotton fiber was removed from the frayed end of R14 and the coating is not as evident as a fiber removed from the surface of the thread as seen in **Figure 5**. The view of the surface of this fiber shows a coating with encrustations and is enhanced by observation in air using episcopic illumination. Original print magnification of Figures 4 and 5 was 315X.

Scanning Electron Microscopy

To determine the thickness of a coating on a fiber it is necessary to prepare a fiber cross section. The fiber or fibers are mounted in a suitable embedding medium sturdy enough to be cut with a sharp blade and sections are cut transverse to the length of the fiber. The resulting sections are observed in a transmission microscope either optical or electron (if the sections are thin enough). The foregoing procedure is called microtomy for the optical microscope and ultramicrotomy for the electron microscope.

The scanning electron microscope (SEM) utilizes an electron beam focused to a spot less than 10 nM in diameter. The sample is placed in the vacuum chamber of the microscope and a beam spot is scanned across the sample in a periodic raster. The emitted electrons from the sample are collected electrically and amplified to form an image on a television type viewing tube.

Instead of viewing sections sliced from the fiber mount we use the SEM to observe the block face from which the sections were cut. **Figure 6** is an SEM view of a plastic block showing a cross section of a Raes fiber R14. Pertinent features are labeled on the micrograph. The wavy patterns in the background are cutting artifacts due to using a glass knife instead of a diamond knife. The epon embedment is a relatively hard resin.

The fiber in **Figure 7** is from Raes 7, a weft fiber. The fiber was at a low angle to the cutting surface and produced a highly elliptical cross section. There is also possibly some compression in the section.

This view shows more encrustation on the surface than the R14 fiber in Figure 6, but the viewer must realize that microtomy is a limited sampling medium and many sections must be cut and observed to establish an average coating thickness along the fiber.

Chemical elements such as C, O, Cl, K and Ca have been detected in the coating, but complete analysis is still an ongoing project.

Acknowledgements

Thanks are due to Barrie Schwortz for expert presentation of various figures made by a variety of techniques.

All microscopy and sample preparation was carried out in the author's home laboratory. Low power optical views were made with a Wild M5A stereomicroscope using Edmunds image transfer optics to an Olympus OM-4 film camera. UV illumination was supplied by a Raytech mineral lamp without extra filters. High power optical views were made with a Leitz Metallux in the transmission mode and in the episcopic mode with Ultropak illuminator. The SEM is an ISI60A.

References

(1) Ogden, J. Gordon, The Use and Abuse of Radiocarbon Dating, New York Academy of Science, Vol. 288, 1977, pp.167-173.
(2) G. Raes, Rapport d'Analise, La S. Sindone, Rivista Diocesana Torinese, 79-83 (1976).
(3) Rogers, Raymond N., Studies on the Radiocarbon Sample from the Shroud of Turin, *Thermochimica Acta,* Vol. 425, Issues 1-2, 20 January 2005, Pages 189-194

Figures

Figure 1. Raes sample weft thread R7. 28X Magnification

Figure 2. Raes sample weft thread R7. 56X Magnification

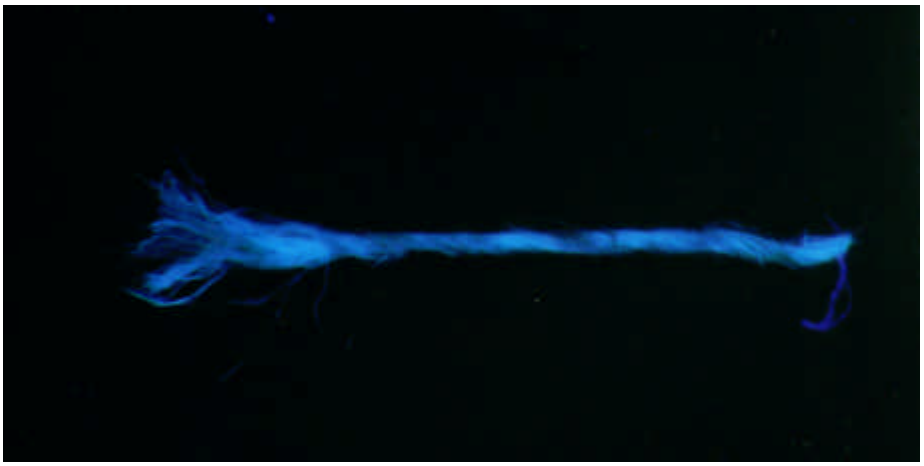

Figure 3. Raes thread R14 with UV light at 254nM. 14X Magnification

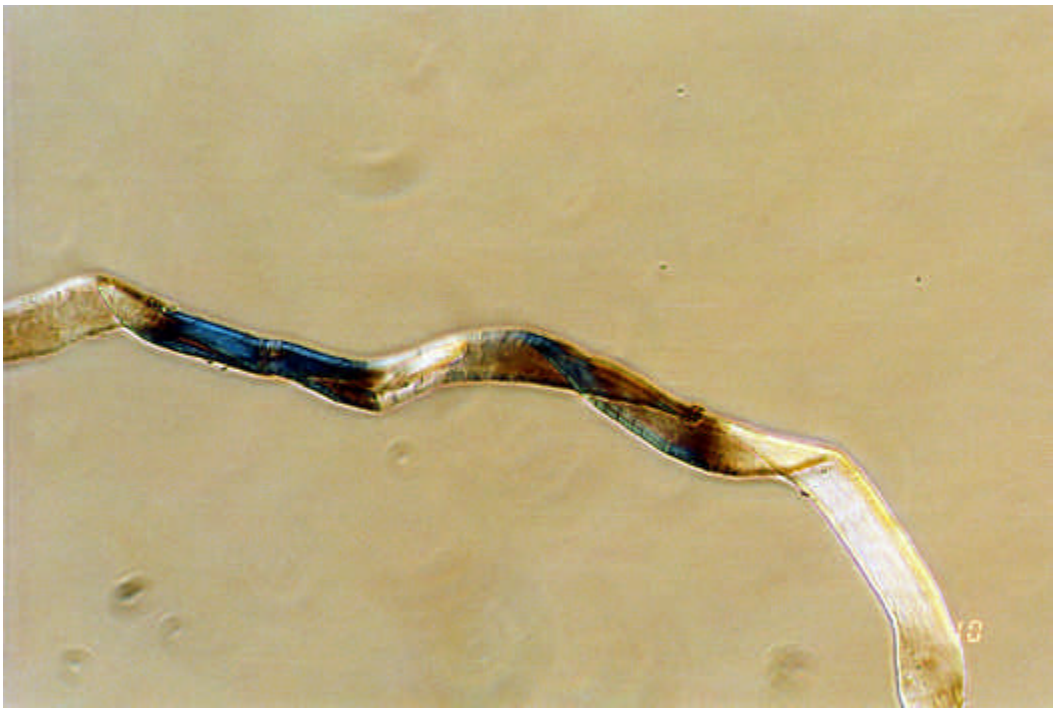

Figure 4. Cotton fiber removed from frayed end of Raes thread R14. 315X Magnification

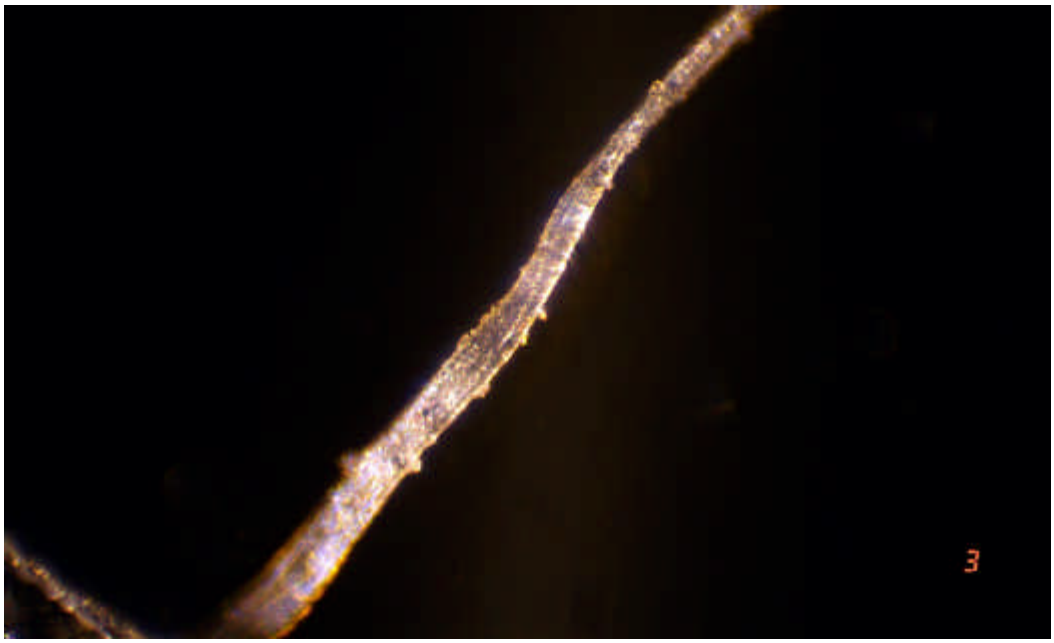

Figure 5. Cotton fiber removed from outer surface of Raes thread R14 showing a coating of encrustations. Magnification 315X

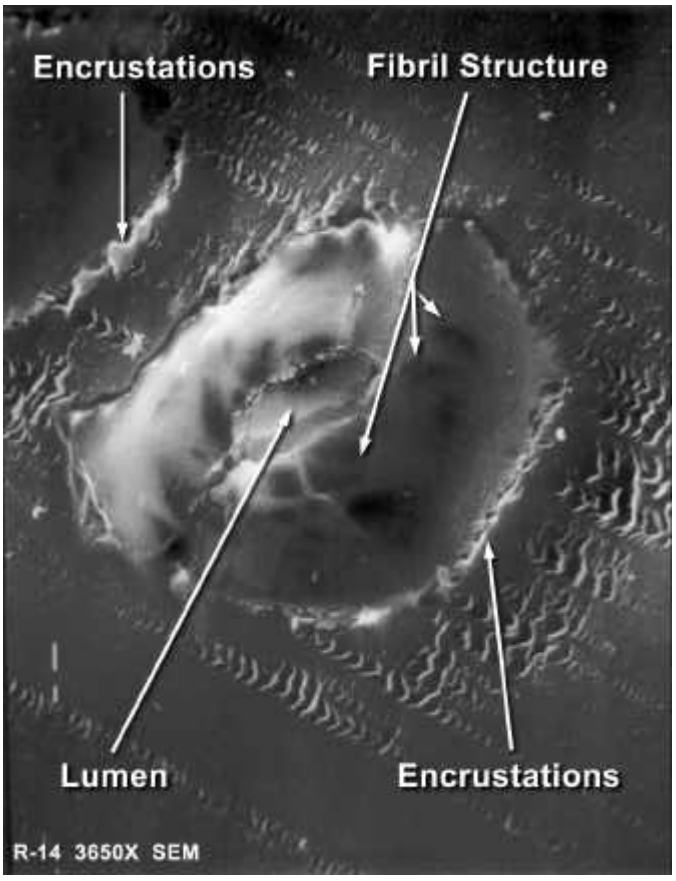

Figure 6. SEM view of cross section of Raes fiber R14. Magnification 3650X

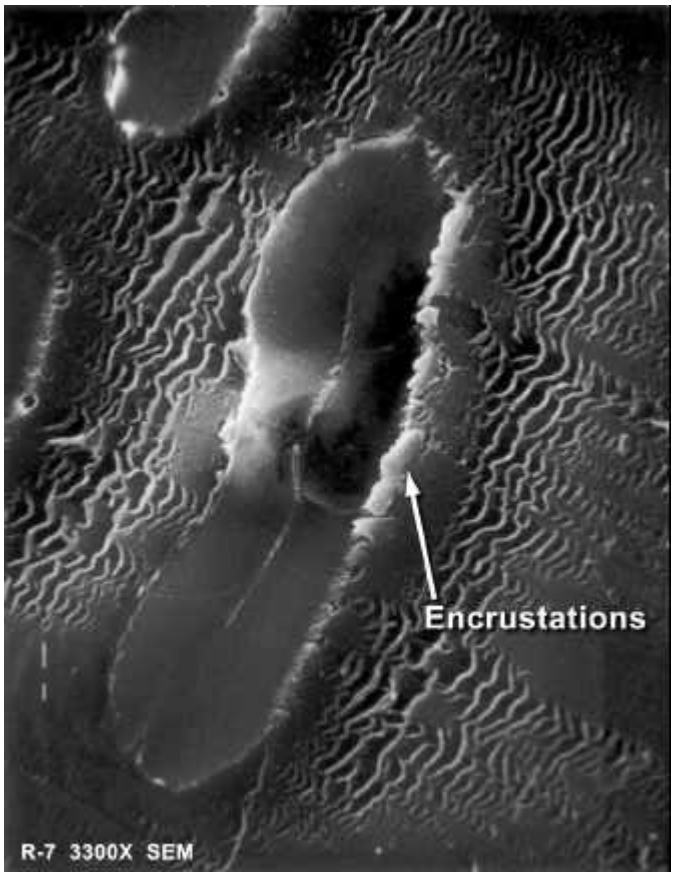

Figure 7. SEM view of elliptical cross section of Raes weft fiber R7. 3300X