

# HYPOTHESES FOR IMAGE FORMATION ON THE TURIN SHROUD

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Three independent groups<sup>1,2,3</sup> have now concluded that the samples used for radiocarbon dating of the Shroud in 1988<sup>4</sup> were all derived from (or at least contaminated by) a patch of medieval linen attached to the original cloth by a process of ‘invisible mending’. This underlines the need for new measurements on very carefully monitored portions taken from a number of sites across the entire Shroud. Meanwhile, the 20 year ‘Winter of Discontent’ generated by the flawed sampling procedure is now hopefully over, and attention may once again be directed towards the problems set by this remarkable artefact.

## CHARACTERISTICS OF THE IMAGE

One of the most recalcitrant questions is the mechanism of image formation. If simple it would – independently of the age of the cloth – have been solved by now! It appears to be agreed that:

- The Shroud exhibits full-size frontal and dorsal images of a naked crucified man. This in itself renders implausible mechanisms more suited to a model – such as scorching with a hot metal statue.
- The depictions are anatomically correct, being far from the usual stylized medieval representations. The images include the hair and beard.
- Both images are in negative, becoming much more apparent and realistic when viewed as contrast-enhanced photographic positives.
- But this does not mean the original Shroud images are photographic negatives in the usual sense, for they are not modulated in terms of the *brightness* of a given feature of the subject. Instead, the intensity of the Shroud image appears to be controlled by the *distance* the cloth would be from a supine body when it is considered to be draped loosely over it and not tucked in. The tip of the nose is therefore in contact, and is the darkest part of the frontal image. No effect is visible beyond a distance estimated to be 40 mm.
- The projection is orthogonal – that is to say the image appears to be at right angles to the causative influence. The latter must therefore rise vertically from a supine body. We note, for example, the ears and sides of the face are not registered. (We are accustomed to this with ordinary frontal photographs made with photons of light selected by a lens, and the eye works in the same way.)
- No particulate pigments have been detected, there is no binder on or between the fibres, and no brush stroke or other directionality has been identified. The image has therefore not been produced by normal artistic techniques – and in addition artists find it almost impossible to paint convincingly in negative.
- Instead, the visible image is produced by a brownish discoloration of the topmost fibrils of the linen closest to the body. (Recently, a very faint rear image has been detected following removal of the backing cloth for conservation purposes.)
- This brown image material is insoluble in organic solvents, but is bleached by very powerful reducing agents such as diimide. It appears to consist of oxidation products of the linen fibres themselves, and to contain conjugated double bonds.

- The ‘sensitivity’ of the cloth appears to vary in longitudinal stripes, presumably as a result of different batches of thread being used to warp the loom. Two stripes are especially apparent on both sides of the jaw of the image, where a lower sensitivity has given rise to an exceptionally narrow face.
- The absence of stains due to fluids resulting from decomposition points to the removal of any corpse in less than three days.
- The lack of any mention of an image in the Gospels or contemporary documents suggests that it may only have become visible after a prolonged period of storage.

## **POSSIBLE MECHANISMS**

This formidable list of criteria eliminates many hypotheses for image formation that have been suggested over the years. Thus, established photographic techniques are impossible in the absence of detectable silver or chromium. Remaining are ‘corona discharge’ and ‘vaporographic’ hypotheses.

### ***Corona discharge***

The image on the Shroud does have a superficial resemblance to those created by placing conductive objects (e.g. leaves or finger tips) upon an insulating plastic sheet covering an isolated metal plate, and then connecting the latter to a source of electrical potential high enough to promote a corona discharge from high points in the object. Use of a transparent electrode enables the discharge to be photographed. This ‘corona discharge photography’, sometimes known as ‘Kirlian photography’<sup>5</sup>, attracted considerable attention from psychics in the decade around 1970-80.

Ancient linens were not scrubbed with synthetic detergents or bleached with chlorine, and could conceivably have reacted to oxidizing ions directed by a vertical field.<sup>6</sup> Unresolved problems are :

- i) Obtaining a sufficiently intense potential gradient in a rock tomb. If ascribed to lightning, could a ‘Faraday cage’ effect operate ?
- ii) Experimental corona discharge images<sup>5</sup> are normally obtained with specimens less than 3mm thick.
- iii) How to obtain a depth-modulated image rather than a filled silhouette?

### ***Vaporographic mechanisms***

#### a) Vignon, 1902; ammonia and aloes

One of the first hypotheses for image formation was that a volatile chemical substance (sometimes identified with ammonia) was released by bacterial decomposition of dried sweat coating the unwashed tortured body of the man in the shroud. Vignon<sup>7</sup> proposed that these alkaline vapours might ascend short distances until, contacting the fibres of his shroud, they reacted with impregnated aloes to produce an insoluble dark coating.

Objections are that there is no sign of a residue of aloes; and why is not a filled silhouette produced by vapours rising from every part of the body independently of its distance from the cloth?

#### b) Rogers and Arnoldi, 2003; Maillard reaction

The Maillard reaction is the interaction of sugars with alkalis to produce intensely-coloured brown products. A familiar example is gravy browning, where a few drops of ammoniated caramel will colour a whole potful of stock. Rogers and Arnoldi<sup>8</sup> proposed that volatile organic compounds responsible for the smell of a decaying corpse (e.g.

cadaverine) reacted with carbohydrate residues on the linen to produce a brown film of Maillard adducts (melanoidins).

It would seem that, as in the related Vignon hypothesis, one might expect a filled silhouette rather than a structured image.

c) Mills, 1995; singlet oxygen

In order to try and overcome the problem of obtaining a depth-modulated image from an ascending reactant, I proposed<sup>9,10</sup> that the latter be unstable, rapidly decomposing as it was carried through the varying 0 – 40 mm gap separating body and shroud.

Extreme instability characterises free radicals, which tend to have half-lives measured in microseconds. However, as it is not strictly a free radical, the active form of molecular oxygen known as ‘singlet oxygen’ has a longer half-life, calculated to be 80 ms at 25° C and atmospheric pressure<sup>9</sup>. Applying the usual rule of thumb that an unstable species is virtually extinct after 10 half-lives, the concentration of singlet oxygen would be negligible after 0.8 seconds. With a 40 mm maximum separation, this leads to a maximum velocity of 50 cm/s for the rising air current that is transporting it. This appears reasonable for linear convection under tranquil conditions, with the source being *Staphylococcus epidermidis* flourishing in dried sweat on skin and hair. Further details and extensive references are given in notes 9 and 10, where it is also explained why it is believed a degree of support is given by:

- The ‘Volckringer patterns’ sometimes to be found on the paper beneath leaves in old herbarium collections.
- The ‘Russell images’ induced in the dark by organic materials placed near (but not necessarily on) early photographic emulsions. Inhibitors to suppress this phenomenon are always incorporated in modern formulations.
- The ‘yellowing reaction’ that afflicts newspapers and paperbacks printed on cheap, unstabilised, lignin-rich paper.
- The common (and harmless) skin bacterium *Staphylococcus epidermidis* is deficient in catalase, so releases hydrogen peroxide and was long ago shown to produce a Russell effect on early photographic emulsions suspended above it. Comparatively recently, Mattingly<sup>11</sup> has drawn attention to this organism in connection with the Shroud, although I differ from him in not proposing that the image be due to actual cell residues adhering to the fabric.

## TESTING THE SINGLET OXYGEN HYPOTHESIS

Pieces of unbleached linen (ideally specially grown, retted and woven) might be stretched on frames and suspended over annuli of inert sponge moistened with a culture of *Staph.epidermidis*. A number of assemblies should be placed in a cool, dry, thermally-stable place (underground?) with some resting on a metal plate heated electrically a few degrees above ambient. Varying ‘exposures’ should be tried.

But who could wait decades for ‘development’? Perhaps the yellowing reaction could be accelerated by placing exposed samples (along with controls) in sealable glass vessels and replacing air with oxygen. The closed vessels with their contents could then be placed in thermostatted ovens at various elevated temperatures, and examined at intervals for a year or more. I regret that I no longer have laboratory facilities for tests of this nature.

## FINAL POINTS

It must be emphasised that neither elucidation of the imaging mechanism nor radiocarbon dating to the first century would positively identify the man in the shroud as Jesus bar Joseph, much less attest to his divinity. This decision rests with the viewer: perhaps this is as it should be.

## REFERENCES

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