Heuristic Reflections on radioactive Mapping of the Shroud

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Finding new ways to investigate the shroud of Turin

The carbon-14 (C14) dating of the shroud of Turin received much criticism in the last few years. Without casting doubt on the honesty of the laboratories, it is possible to criticize their final published results for the following reasons:

1. ***The large discrepancies*** between the Oxford laboratory and the two others (Zurich Switzerland, and Tucson Arizona which differ by about 100 years for an estimated age of about 700), as well as the *spreading of the confidence range* for the experimental results, need to be explained. In the case of the shroud, the *Significance Level* (S.L.) was the lowest one, and has been estimated at 5%[1], which means that the measured samples may be non-representative.
2. ***The shroud has been regarded as a common archaeological artifact***. Due to its complicated history, the shroud is a very special case, because of many possible contamination of C14. It was not a mummy cloth sealed during 2000 years in a sarcophagus, before going to a modern laboratory. The linen has been transferred here and there, often manipulated or restored, exposed several times to fires and smoke, exhibited and venerated with candles, incense, etc., and it claims a supernatural origin. That is to say: science must analyze it with care and completeness.
3. ***Protocol definition could have been better***. The local sampling in one corner of the shroud was not very judicious, because it eliminated the possibility of verifying the uniformity of the C14/C12 ratio of the shroud. If some enrichment in C14 (which makes the linen look "younger") worked in the past, it would scarcely have been spread homogeneously over such a great surface (4.36 x 1.10 m²) which was often folded. This article tries to consider various scientific methods that would not close the door to possible new interpretations.

Signs of non-uniform C14 distribution: is there a "radioactive image" hidden in the linen?

The available measurements exhibit a variable C14/C12 ratio over a few centimeters. This is not necessarily due to some experimental errors, as the laboratories suggest: it seems to point out that ***the shroud exhibits a non-uniform C14 map***. Instead of studying this possibility, the three laboratories spoke only in terms of mean date[2]. The most plausible and logical interpretation is that the *three samples did not exhibit the same C14/C12 ratio*. One may then reject the given measurements as those of non-representative samples of the shroud. Consequently, it would be necessary to take better samples. But one may also consider that the amount of C14 is not uniformly

[1] Why should we accept such a low S.L.? Besides, R. Van Haelst estimated that the S.L. is actually equal to 1.3%, which should definitely give an unacceptable dating. E. Brunati has the same critics (see a discussion in O. Petrosillo, E. Marinelli, *La Sindone*, Rizzoli, 1998, pp. 213-214; 227-228).

[2] See **Nature**, 337, feb.1989, pp. 611-615. Here is a summary of the results:

Samples	Arizona	Oxford	Zurich	Mean	Chi^2	Significance Level
1 : Shroud	**646±31**	**750±30**	**676±24**	**689±16**	**6.4**	**5 %**
2 : Nubia tomb	927±32	940±30	941±23	937±16	0.1	90 %
3 : Egyptian mummy	1995±46	1980±35	1940±30	1964±20	1.3	50 %
4 : Louis IX of France	722±43	755±30	685±34	724±20	2.4	30 %

(Dating is in "Years Before Present")

distributed over *the whole surface* of the linen due to some unknown C14 implantation/removal process. Such divergent measurements on samples taken out of a 7 cm² area, let us suggest that there may be wider variations for distant samples.

Besides, it is claimed by several people that two non-official measurements were made between 1979 and 1982, which corroborate this last hypothesis. The three 1988 samples were practically taken off in the same zone, a corner of the linen (see fig. 1: sample A was delivered to Tucson Arizona, B to Zurich, C to Oxford). In addition to those official samples for dating, there was also the 1973 sample, given for textile analysis to Prof. Raes, at University of Gent (Belgium). In 1979-1982, one of the three pioneers of the new AMS technology, Prof. Gove (University of Rochester), and his colleague Harbottle (Brookhaven National Laboratory), seemed to have conducted two dating measurements of this sample: the two results diverged greatly, not only between them (1750 and 950 years B.P. - Before Present), but also with the later official measurements of 1988. The contamination seems quite inhomogenous. One of the hypotheses is a middle-age restoration of this part of the linen with non-uniform use of starch[3].

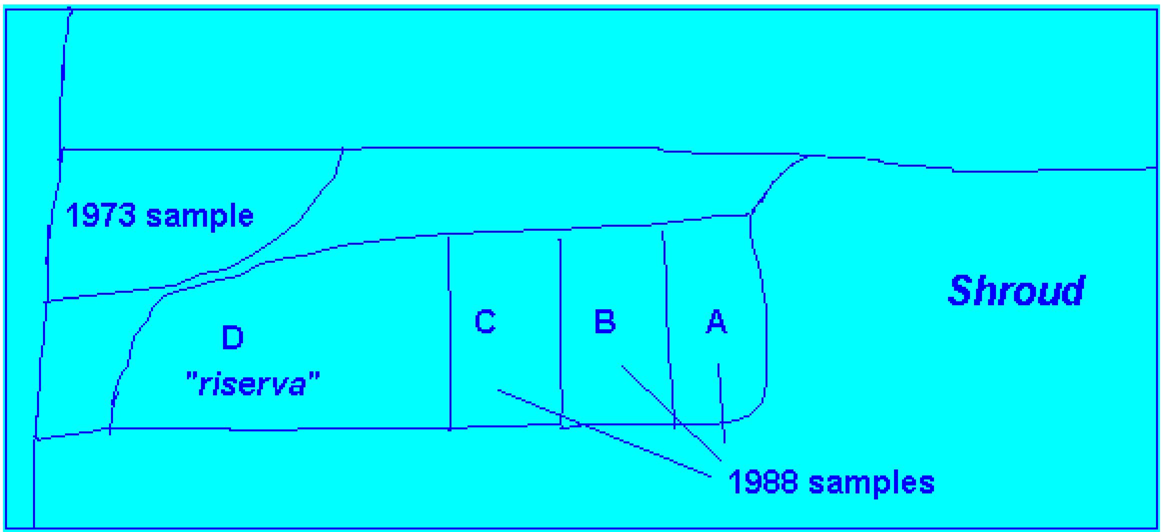

Fig. 1 : Sampling zones of 1973 and 1988.

But M.-C. van Oosterwyck Gastuche[4] graphed the 5 dating results, showing some radioactive shifting between internal parts and the border of the shroud. The unofficial measurements supposedly made in 1979-1982 by Gove and Harbottle[5] were not only regarded as unreliable: it could eventually throw some suspicion on the validity of their new AMS method. The results were then silenced. Some scientists argued that the 1973 samples were not cut off in presence of Prof. Raes, and may have been contaminated or even substituted. This late assertion seems quite improbable to me: Prof. Raes received the sample only for textile analysis and kept it in what looked like a scrapbook for postage stamps before returning it to the Church[6].

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[3] Cfr. O. Petrosillo, E. Marinelli, op.cit. p. 267.

[4] *Le sel de la terre*, n°20, 1997, pp. 32-54; reproduced in figure 2.

[5] Prof. W. Meacham wrote me in a personal communication that John Heller said him that the dating was done at some accelerator in California (University of California?). See also the mention in Sox, H. David, *The Image on the shroud.* Unwin, London, 1981, pp. 161-167.

[6] Prof. Raes related recently to me by phone that he was contacted to deliver his sample for dating, but he preferred to return the sample back to the Church.

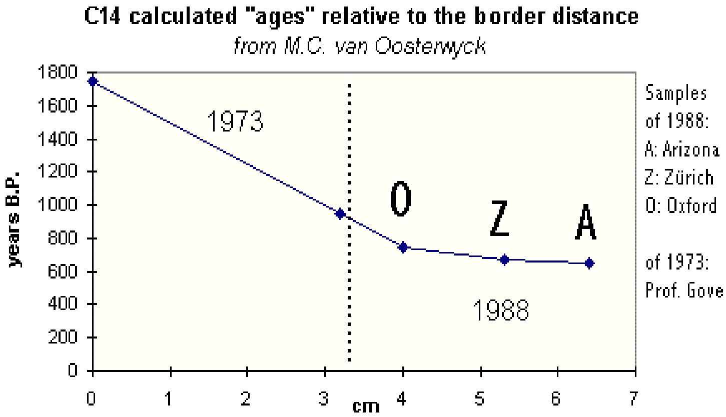

fig. 2

Moreover, and it is noteworthy, *if there had been contamination, the dating measurements of the linen samples should have looked younger than the carefully cleaned samples of 1988 (i.e. an age lower than the estimated 750 years), but it seems that we observe two much older measurements, of 950 and 1750 years respectively!*

What's more, there are some paintings of the Christ's shroud very similar to the shroud of Turin, which clearly predate the results published by the three laboratories. One example is the *Pray Codex* found in Budapest, authenticated to at least 1192 and probably painted around the year 1150. All those *anomalies* with respect to the dating of 1988, need to be addressed.

If a carbon-14 contamination is present with non uniform distribution and implanted in the body of the fibers, it is impossible to date the shroud by the C14 method. A pollution of the linen may at first sight explain such a variation in the three measurements, but the laboratory specialists were confident in their ultrasonic cleaning procedure and the microscopic screening they used, which should guarantee the cleanliness of their samples. This hypothesis may not be right. In retrospect, it is of the greatest importance to determine the homogeneity of the C14 percentage over the shroud surface, especially after the strange measurements made in 1988 (and eventually in the early 80's, if they are confirmed) even after cleaning. Besides, after analysis of the data, *the various cleaning processes used didn't seem to significantly affect the results. The contamination process does not appear to be superficial.*

A complete isotopic analysis would have been preferable

The absence of isotopic analysis is also regrettable. Why did we limit measurements to the amount of C12, C13 and C14? As we are not able to explain the formation of the image, the isotopic content, particularly the radioactive elements, would give us some valuable information on the linen composition and the various influences it was subject to. A complete isotopic analysis of future samples may also lead to an indirect dating in case of induced radioactivity by some unknown process.

Nevertheless, the experiments to be done would have to preserve maximally the shroud's physical integrity, as it seems as a special relic for a lot of believers. The experiments to determine isotopic content are unfortunately destructive. Therefore, they would have to be restricted to a minimum if we do not want to destroy the shroud little by little. Other more delicate methods are not destructive and are virtually infinitely reproducible.

Proposed experiments

1. New representative samples

Several years ago, I proposed some techniques to map the shroud's radioactivity[7]. The divergent measurements presently available, which tell in favor of non-uniform distribution, cannot definitively settle the question, because of the unfortunate nearness of the chosen sampling zones. The mysterious complexion of the shroud's image formation (which appears as a very superficial scorching more or less browned) demands more caution with respect to the choice of the sampling zone for dating. It would have been better to select different spots in order to be able to differentiate the C14 amount within several zones (body picture, bloodstains, peripheral zones, front and back of the linen, superficial or inner fibers, etc.). Furthermore, in the case of accumulating strange dating in the future, scientists will probably continue to ask for further sampling, because it might then be seen as another non-representative sampling. So, let's be wise this time.

a) My first proposal meets the group of scientists which favors the taking of **new representative samples**[8]. We can measure the superficial radioactivity by cutting *samples* at several carefully selected places spread over the shroud: the visible browned image, some peripheral zones, front and back surface of the linen ("slicing" the top and bottom faces apart), the pieces added for repairs, superficial or inner fibers, etc.
b) Slightly destructive methods may also allow us to analyze the ***complete isotopic composition*** of the previously chosen samples in distant areas. The results can give us an idea about the formation of the image.

The obvious drawback is the destruction
ntegration events. In order to evaluate the time to scan, I assumed that the shroud's radioactivity is only due to natural C14. It may not be so: an enrichment of C14 or of other radioactive elements should reduce this estimated time. Nevertheless, rough evaluation of maximal time to get a picture is possible: it amounts to several weeks.

Contacting several specialists, I received divided opinions over the technical feasibility of this kind of measurement[9]. The radioactivity which needs to be measured is of the same order of magnitude as the natural radioactivity (I insist that it can also actually be higher). Some scientists assert that the present measurements of ambient radioactivity are sufficiently accurate (they perfectly estimate variations of background radioactivity): but nothing more is asked for the proposed measurements.

This measurement process is comparable to neutron activated autoradiography used with paintings[10]. The longer the time of measurement, the more accurate will be the radioactive map. Besides, there are some methods to filter out the spurious background measurements. Among the various technically possible methods I suggest:

1. In order to perform non-destructive experiments, a cheap and easy method can be the use of a ***thin end-window Geiger-counter*** to scan the radioactivity. The window must be thin in order to avoid the absorption of $ß^-$ particles (maximum energy of ± 150 KeV for C14 is quite low). The calculation shows that this $ß^-$ absorption in common materials is total after a distance of a few tenths of millimeter, but several centimeters in gases like the air. Besides, the linen absorbs the inner $ß^-$

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7 Dalleur, Ph., *Sindone di Torino: Tests non-distruttivi?*, Collegamento pro Sindone, 1995 July/August, pp. 19-27; *id., De Lijkwade van Turijn : Dateringsproeven mogelijk zonder schending van het linnen?,* Soudarion, Brugge, 7, nr.3, dec. 1994, pp. 8-10.

8 Prof. Meacham proposed a minimum of 5 sampling zones in his article *Turin shroud - Image of Christ?*, Acts of Hong Kong Symposium, march 1986, pp. 52-53.

9 Prof. Ph. Albert (France) asked Packard Instrument to perform a preliminary test of feasibility with their sensitive detectors. The detectors were able to discriminate very low radioactivity levels. I also contacted the Modane laboratory who concluded their preliminary experiments saying that the presence of radioactive potassio is a source of errors in the mapping of C14 distribution.

10 The question is certainly not to irradiate the shroud, neither to date it by counting measurements, but to measure *grosso modo* the distribution of its "natural radioactivity" over its surface.

particles, showing a well known statistical energy distribution[11]. If the radioactivity has been activated or disactivated superficially, it would give another kind of energy distribution (less or more spread respectively). This can show a 3D C14 distribution, and not just a surface (2D) one.

2. Another much more elaborate possibility is similar to biological or artistic techniques of ***autoradiography.*** I know two ways to perform autoradiography:
   - *film contacts* (photographic emulsions sensitized to $ß^-$ radiation, for example): it is relatively cheap; if the total radioactivity level of the browned zones is adequately high, it may be as simple as the discovery of radioactivity by Becquerel in 1896.
   - *Scintigraphic scanner* (with semiconductor detectors, for example, or proportional chamber, etc.): this technique can be completely computerized, making the digital picture-filtering easier. Semiconductor detectors based on micro-strips or CCDs are particularly interesting. Some specialists say that proportional chambers techniques give a sensitivity 1000 times higher than the conventional film autoradiography[12].

Those techniques are more or less complicated. The proportional chambers should be placed close to the shroud, with a thin window like the Geiger-counter. The semiconductor technique should even be able to make measurements without any window.

1. If the results of former experiments were convincing, it would be convenient to analyze the spatial correlation between the radioactive measurements and the visible image. We will see if an invisible radioactive map of the body, integrated in the shroud's fibers underlies this image, or if some other radioactive ion implantation took place independently of the image formation (like the effects studied by Kouznetsov or Garza-Valdès[13]). In any case, reducing the noisy background radioactive influence in the measurements would be valuable, and perhaps necessary, to detect any variation of radioactivity. There exist several techniques to perform the filtering:
   a) *Shielding* (with high and low Z number materials [respectively lead and polystyrene, for example], underground laboratory (the Italian *Gran Sasso* laboratory or the *Modane* laboratory), or any low radioactive place far from cosmic ray influence, etc.);
   b) *VETO* filters ("sandwich" detection) eliminate a great number of spurious counting of external events (cosmic rays, ambient natural radioactivity);
   c) *Temporal integration* of the results using digital filter techniques, spatially and temporally. This will allow refining eventual "radioactive images" when results accumulate with the passing of time.

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[11] Cf. for example W.R. Leo, *Techniques for Nuclear and Particle Physics Experiments* Spinger-Verlag, 1987, pp. 40-50. or K.S. Krane, *Introductory Nuclear Physics,* Wiley & Sons, 1988, pp. 196-197. If there has been some significant local C14 enrichment, or if more energetic elements are present, it will be easier to measure. But the results of my calculations only assume naturally occurring C14 radioactive source.

[12] Among the modern autoradiographic techniques, the MSA-MWPC (MultiStep Avalanche - MultiWire Proportional Chamber), used since 1985 in electrophoresis and chromatography, can give a radiographic map (e.g. for DNA sequencing) using radioactive $ß^-$tracers like C^{14}, P^{32}, S^{35}, H^3, etc. Its sensitivity is excellent (1000 times higher then the film technique), and its spatial resolution is better than 1 mm. Films must remain in contact with the sample several weeks or even months. With this new technique, a few hours are enough (Cf. Webb, S., *The physics of Medical Imaging,* in *Medical Science Series,* 1990, pp. 171-181, 309-318). The measurements on the shroud should be performed with a sensitive autoradiographic detector in the low energy band (50 to 500 KeV) shielded maximally against spurious sources of radioactivity.

[13] Notice that if some "Kouznetsov or Garza-Valdès" effect took place in the past, the amount of transferred C14 or C13 ions was probably greater in the exposed faces of the folded shroud and eventually in the zone near the silver frame than in the protected inner zones. This should lead to a differential "stair-level" effect which might be seen with the techniques I propose here. Furthermore, the strips of the herringbone cloth structure of the shroud seems to have had some influence on the sensitivity for the image formation, because they seem to be correlated to some visible stair-level effect. Maybe this was due to the bleaching process, or to some temporary coating used which spread itself more or less following the twilled strip structures.

Conclusions

It would be convenient to constitute a *scientific committee* to determine experimental ways and steps to follow before transmitting them to the Vatican, or to the official Custodian (at present archbishop Mons. Severino Poletto), in order to launch new experiments. The steps I proposed are the following:

a) To begin, try cheap techniques:

1. Take off a few samples in several significant places (as described above in Proposed experiments, 1, a) and perform a complete *isotopic analysis*. This step must be left out if no destruction is allowed.

2. use non-destructive techniques like *film contact* and/or a *thin window Geiger-counter*, to compare the radioactive levels of different selected places;

b) In the case of positive results, go on with elaborate experiments (ultra sensitive shielded *scanner*, with filters and digital processing, statistical analysis of correlation with the visible image).

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Vai alla pagina dell'indice - Go to the index page