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# ON CARBON DATING THE TURIN SHROUD

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In recent discussions on the possible authenticity of the Turin Shroud (Sox 1981; Meacham 1983; Jumper *et al* 1984), the question of the value of C14 dating persistently recurs. Virtually all researchers agree that the test should be performed; sufficiently small samples can now be measured so that the appearance of the relic is not altered. Several C14 dating proposals are now under consideration by the Archbishop of Turin.

In contrast to these positive developments, however, there appears to be an unhealthy consensus approaching the level of dogma among both scientific and lay commentators, that C14 dating will "settle the issue once and for all time." This attitude sharply contradicts the general perspective of field archaeologists and geologists, who view possible contamination as a very serious problem in interpreting the results of radiocarbon measurement. In this paper I shall examine the issue of the reliability of C14 testing to produce an "absolute date" on the linen sheet known as the Holy Shroud of Turin and believed by some to be the gravecloth of Christ.

The radiocarbon measurement of the Shroud is a complex issue, and the inclusion of all relevant expertise is highly important. In May, 1985, I submitted such a proposal to Cardinal Ballestrero, Archbishop of Turin and official custodian of the relic, in the hope that the ecclesiastical authorities would consider appointing a scientific panel to plan and implement a C14 testing program.

The first proposal to date the Shroud was submitted in 1979 by Gove and Harbottle (published in Sox 1981:161-167). It was, in my opinion, seriously flawed by the lack of consultation with archaeologists and experts from other fields. Although the more recent STURP proposal has not yet been published, there is reason (discussed below) to suspect that it likewise has not been researched to the degree warranted by the object to be dated, and that significant input from a range of scholars is lacking. Because the next round of scientific testing of the Shroud may well be the last of this century, it is imperative that such details as the amount and number of samples and especially the sampling sites be very carefully considered. Possibilities of contamination should be exhaustively investigated, and pretreatment should be devised accordingly.

The 1979 STURP-sponsored "Gove/Harbottle Proposal on Carbon Dating the Shroud" (Sox 1981:161-167) outlined only standard pretreatment of the samples for carbonates and humic acids. It did not propose scanning electron microscope screening or other types of direct examination to check the state of the samples prior to testing—an omission which might have been rectified if the vicissitudes of the cloth over the centuries had been stressed, as an archaeologist would have done. Much worse, the 1979 proposal involved a small sample of cloth removed from the Shroud in 1973 for study by Prof. Raes of Belgium. McCrone and Sox had inspected the sample (apparently unstitched by Raes into two pieces) during a visit with Raes in 1976, and found that "the samples were kept in what looked like an old scrapbook for postage stamps" (Sox: 1978:48). Certainly most archaeologists would have rejected the use of samples subjected to a long separation from the object to be dated and held under unknown conditions of storage and handling.

Further, McCrone (1978:440) made his contribution by proposing to rely on "the person authenticating the Shroud samples as the same ones studied by Raes." (The original sample was apparently not even taken from the Shroud in the presence of Raes.) An art historian would certainly not have been satisfied that such a procedure could establish conclusively that the pieces were indeed from that sample removed from the Shroud in 1973, and that it had not been tampered with in the intervening years. Finally, the original sample was taken at the junction of the side strip (believed by some scholars to be a later addition) and the (selvage?) border (possibly treated to prevent unraveling, and certainly more subject to contamination than the main body of the cloth). It could not be considered as a typical or representative sample of the relic. In sum, the proposal to use the Raes piece for C14 dating was not an academically sound proposition; it was based on expediency (as the pieces had already been removed from the relic and were "available"). There is consensus now that, had the testing been allowed, it would have been the cause of great controversy regardless of the results. Yet Gove, in urging the release of the Raes samples, wrote that "at long last, the Shroud of Turin's true age will be established in the near future."

Before considering the recent proposals for dating the cloth, it is useful to survey the major problems routinely encountered in the field of C14 dating.

**General Considerations of the C14 Method**

Even among social and physical scientists, there are numerous misconceptions about the radiocarbon method of dating; among journalists and the general public there are, of course, many more. But among specialists who frequently make use of

the test, it is not considered as a method which produces a correct calendar date for every sample that can be measured. When I wrote in *Current Anthropology* (1983:289) that C14 dating could not be expected to settle the matter of the Shroud's age and authenticity because of the possibilities of contamination, there was a storm of criticism—virtually all of it motivated by ideal sample considerations and obviously not tempered by experience in using the method. Stuckenrath (1966:277) certainly had it right twenty years ago in his remark that "C14 dating is, after all, only another tool for the archaeologist, but it behooves us, before attempting to use it, to know which end has been sharpened."

In both the *Current Anthropology* comments and in Shroud writing generally, there is exhibited a lack of awareness of the pitfalls and uncertainties inherent in the C14 method. To quote from the comments: Alcock said it was "sheer whimsy" to raise the question of contamination; McCrone claimed that "the impurities can be readily removed before dating, hence this argument has no validity"; Maloney thought that "the margins of error supplied with each date [give] a measure of accuracy" in the elimination of contaminants; Schafersman claimed that the idea of contamination was "absurd". In the Shroud literature, a similar absolute belief in the method is encountered among most writers. Wilson, for example, states (1978:264) that a dating accurate to a plus-minus of 100 years is possible, thus "enabling the settling, once and for all, of the question of whether or not the Shroud is a XIV$^{th}$ century forgery." Sox (1981:132) follows Wilson in thinking that C14 dating of the Shroud could "remove it once and for all from the Middle Ages, or place it squarely there for all time." Some STURP scientists display similar beliefs. Jumper *et al* (1983:176) claimed that the test "if 'negative', i.e., not first century, can *prove* lack of authenticity" (emphasis added). Dinegar, who heads the STURP C14 group which claimed to have made a detailed study of the application of C14 to the Shroud, stated that "sample preparation procedures can *insure* no error in date due to foreign contamination accreted over the centuries" (1982:6; emphasis added). As I stated in my submission to Archbishop Ballestrero, this line of thinking is mistaken: "It is a very serious error indeed to proceed with C14 dating on the assumption that it is an infallible method."

All of the above statements quoted from the literature reveal an unwarranted trust in radiocarbon measurement to produce an exact calendar date for any good sample submitted. Even the most elementary textbooks of archaeology and geology give a very different picture. "Contamination of samples may cause error in determination of reliable dates" (Heizer and Graham

1967:165);...contamination of the sample may take place...and removal of the contaminant from the pore spaces and fissures is *almost impossible*" (Goude 1977:10; emphasis added). "Carbon from other sources may easily be trapped in porous materials.... The archaeologist is the only person who is in a position to know of these contaminating potentials" (Stuckenrath 1965:279). Excavated samples are "liable to absorb humic matter from the solutions that pass through them [resulting in] contamination by carbon compounds of an age younger than its own.... there is also the possibility of exchange of carbon isotopes under such conditions.... That there are other risks of contamination and other pitfalls involved in this method is obvious enough" (Zeuner 1970:341-6). Stuckenrath noted that contamination could not always be detected or eliminated, even with specialized pretreatments. He cited discrepancies in dates of wood house-posts in Alaska at 1800-1600 B.C. and of charcoal from hearths within the houses at 1000-800 B.C. Summarizing the attempts to date early man in North America, Wormington (1983:191) stated what must be a nearly universal view among archaeologists: "Over the years, we have learned that radiocarbon dating is not quite the alchemist's stone we once hoped it might be."

For most C14 samples, the burial history is known or can be reconstructed, and substances possibly affecting the carbon content can usually be identified. For the Shroud, there is a 600-year history in a number of different environments and uncertain handling situations, and a possible further 1300-year existence during which the object could have been in contact with virtually any natural or man-made substance in the areas it was kept. To measure Shroud samples, one must therefore consider every possible type of contamination and attempt to identify and counter every one, before the actual measurement is made and a "radiocarbon age" (a term generally used by archaeologists and geologists) is assigned. Clearly, this result can only be considered as a possibility, at best a good probability, but hedged by many uncertainties. It would not be an absolute calendar date, and it would not "prove" the Shroud to be authentic or a forgery. Rather, it would be one further piece of evidence to be evaluated in the light of the total complex of data about the Shroud. As Barnard (1980:34) observes: "No historian would, for instance, point to a radiocarbon date (or even a whole series of C14 dates) and assert that this type of data...provides ultimate proof of the reliability of a certain point of contention."

Such a restricted use of C14 results is commonplace in archaeology and geology; many "dates" are rejected as anomalous and in conflict either with other C14 dates or more reliable data. These

common limitations in the use of C14 results are apparently not known to or not appreciated by most Shroud commentators of whatever predisposition and academic training. Surprisingly, only the Jesuit historian Wild (1984:38), in an article bristling with errors and non-sequiturs, made a fairly accurate summation: "...test results showing a late date would be attributed to contamination, a not unreasonable suggestion in the light of everything the Shroud has been through." Codegone, the Turin physicist whose advice was sought by the Cardinal in 1973, and who has been the object of much criticism for his lack of familiarity with the small-sample technology coming to the fore at the time, was absolutely right about the problems: "...the sacred linen has undergone vicissitudes which could have altered its composition [and which] give rise to grave uncertainties" (1976:37; translation mine). On the other hand, Foley (1982:26) has raised false issues about sunspot activities, C14 decay rate, and counting accuracy. But I have not yet discovered in literature the claim "of some people" reported by McCrone (1983:298) that "the resurrection so modified the linen that any carbon date is bound to be meaningless." There is, however, a remote possibility that volcanic activity in the region where the Shroud linen was produced, or even atom bomb testing of the last 40 years, may have done so.

In another, more detailed version of this paper (Meacham 1986), I have described the types of contamination and other causes of fictitious ages that sometimes occur in shell, bone and clay samples, even in wood and charcoal, which are the ideal sample materials. Suffice it to say that there are examples (well known to radiocarbon daters) of objects certain to be several thousand years old giving C14 dates into the future, and conversely, of objects recently dead giving dates of several thousand years. These are, fortunately, rare occurrences; the major problem in C14 dating is that of contamination. Betancourt *et al* (1979:202), for example, discuss several dates that are too late in the historical chronology of the Aegean and conclude:

> One or two dates should never be used by themselves to establish a site's chronology. So many dates have proven to be useless because of contamination and other causes that one can only establish a radiocarbon chronology with some degree of confidence if several dates from the same site fall into a consistent pattern that agrees with the stratigraphic sequence.

It is clear that "more research on dating technology needs to be conducted so that the reliability of dates can be assessed" (Stanford 1982:205). MacDonald (1983:100, 108) believes that-the injection of humates from ground water may have seriously contaminated many dates from the northeastern United States with its particularly acidic soils:

> The critical question that demands immediate attention is that of humic acid contamination of C14 dates, since there is growing evidence that current lab pretreatments are inadequate and that we are confounded by dates that may in some cases be too old and in other cases too young...

In sum, it should be obvious to the non-specialist, as it is to most archaeologists and radiocarbon scientists, that possible contamination *always* represents an element of uncertainty which no amount of laboratory pretreatment or measurement can totally efface. Clusters of congruent dates on different materials, replicated at different sites, eventually allow for a reliable radiocarbon chronology to be established, but there is, quite simply, no possibility of an "absolute" date on a single sample or artifact. As Liddy (the inventor of the C14 method) is supposed to have remarked: "There are *no* absolute dates."

**Carbon Dating the Shroud**

The fact that significant discrepancies do often result from contamination in best sample materials from optimum archaeological conditions has major implications for C14 measurement of the Shroud. First and foremost is the abandonment of any notion that a radiocarbon age of whatever magnitude will settle for all time the question of authenticity. Second, an elaborate pretreatment and screening program should be conducted before the samples are measured. Third, the choice of sampling sites on the relic should be governed by considerations of possible contamination and by the desirability of measuring both typical and atypical samples. Finally, the result should be interpreted to the general public in the light of contamination and other uncertainties inherent in the radiocarbon dating method.

Undeniably, a "bull's-eye" result with mid-point at 20 or 1320 A.D. would lend strong support to the proponents or opponents of authenticity. But a result of 300 or 700 or 1000 A.D. would create more controversy than it settled, especially with the necessary margin of error at ± 300 years or more. As flax is extremely short-lived, minor fluctuations in atmospheric C14 levels probably require that an uncertainty of ± 120 years (Farmer and Baxter, 1972) be added to the normal statistical errors ( ± 80 on a good sample). Calibrated and reported at 95% confidence level, the radiocarbon age of the Shroud will probably span 600-800 years. It is of course futile to speculate in advance on the interpretation of results, and I shall proceed to a consideration of the types of contamination which may be present on the Shroud, and of other factors which may influence the C14 result.

The main contamination possibility is that of carbon from organic materials deposited in the porous cellulose structure long

after the Shroud was manufactured. One source would be mold, mildew or other fungal growths which are encouraged in linen by high humidity environments. Hydrocarbons could be deposited in the pore spaces and cell walls, gradually displacing the original cellulose of the linen as it degraded. With frequent handling, stretching, creasing, etc. the Shroud may have been more subject to hydrocarbon entrapment than would a buried specimen undergoing natural decay. Bacterial or insect residues and fine particles of carbonates could similarly become locked in the cellulose structure.

Substances introduced by man over possibly 2000 years constitute another category of contaminants, and some of these may have interacted with the cellulose. Penetration of the pore spaces may have occurred and a water-soluble, carbon-bearing solute deposited therein. The bound water of hydration may have been penetrated by other substances; lipids and proteins may have been deposited among the fibrils; smoke may have left free carbon deposits within the pores. If this catalogue of contamination possibilities seems overly pessimistic, one must bear in mind the various substances recorded to have been in contact with the relic since 1356—oils, wax, soap, paints, ointments, open wounds, saliva, sweat and smoke. Preservatives, starch and image-enhancers may also have been applied. Earlier, the cloth may have been sealed in a city wall for several centuries with a votive oil lamp, and the relic may have been attached to a wooden frame for additional centuries, absorbing decay products from the wood cellulose. Some of the penetrating organic substances may, through time, have degraded to low order residues not detectable as specific contaminants and shielded by the cellulose substrate.

It is quite conceivable therefore that more recently formed organic compounds may have been absorbed by the linen, and that these residues may be in various, relatively active stages of alteration and degradation. Like charcoal, the open cellulose structure of linen, especially aged linen, is highly porous, with large surface areas, and is particularly absorbent of organic substances in solution "which can subsequently only be dislodged with difficulty" (Burleigh, 1974:82). Fractions removed from the sample by selective chemical treatment should each be dated. With increasingly intense extractions, the results should be progressively older, approaching that of the final residue. This residue would represent the original cellulose of the linen if there were no contaminants equally or less soluble than the sample itself. The idea of dating two or more chemical fractions on each sample has not to my knowledge been suggested for Shroud samples, but it would certainly be of greater scientific value than dividing up each sample to provide material for six laboratories each to run a conventional test. Checking of results

between two or three labs is a reasonable proposition; to engage six labs to run a similar test on each sample is unnecessary.

The other side of the contamination coin is that ordinary pretreatment would remove many of the intrusive substances; analytical methods would indicate the presence or absence of other contaminants and suitable procedures applied for their removal. But there is no doubt that the Shroud has had an enormous exposure to a host of contaminants during its history. Marano observed under the SEM that Shroud fibers had a "filthy" appearance caused by "abundant deposit of extraneous pollutant material intimately connected with the individual fibers of the cloth" (1978:202,381; translation mine). Most if not all of the larger particles, such as pollen and insect debris, would be removed in ultrasonic washing, but unidentified "nodes" on the cellulose fibers require further investigation. In addition, there are numerous intrusive fiber remnants which would need to be painstakingly removed, if possible. Whereas all radiocarbon laboratories advise against placing a paper label in contact with the sample for the few weeks in transit from field to lab, the Shroud has had a backing cloth for 450 years!

Contamination considerations also bear on the question of sampling sites. Recent STURP C14 proposals (Schwalbe and Rogers, 1982:44; Adler, 1984) have centered on the charred cloth hidden under the patches and thus removable without altering the physical appearance of the relic. While this charred material should certainly constitute one of the samples, it would be the gravest of errors, in my view, to take it as the only or the principal sample. The folded corner of the Shroud was burned suddenly at a very high temperature, in probably a reducing atmosphere, in the presence of volatizing organic materials possibly 1500 years younger in age. There are numerous contamination possibilities in this event, and few if any C14 dates on comparable samples.

The fire in 1532 at the Sainte Chapelle in Chambéry had begun to melt the silver casket in which the Shroud was kept, folded into 48 layers. By the time the relic was rescued, molten silver (probably at 850-900° C because of alloys) had dropped onto the cloth, burning through one corner and charring the lines of the folds. If, as seems likely, the folded Shroud was kept in a silk pouch and the interior of the casket had a velvet lining, then there is a possibility that the pyrolysis products of these cellulose materials could have been transferred, even if in minute quantities, onto the Shroud. This transfer could have occurred by direct contact or air-borne movement ("smudging" in ceramic technology) whereby the colloidal carbon and tarry products of combustion permeate the pores of the cellulose in the reducing atmosphere inside the casket.

There may also be carbon from combusted, cracked hydrocarbons of intrusive materials present on the Shroud at the time of the fire. In a 1503 chronicle, there is mention of the relic being boiled in oil as a test of authenticity. Substances from this oil bath could have been present in quantity on the cloth in 1532, though none can be detected today. Carbon from these substances may have been incorporated in the carbonized linen as microscopic soot-like particles or as sub-microscopic colloidal carbon amongst the micro-fibrils. Outside of the charred areas, the uneven distribution of pyrolysis products has been suggested (Schwalbe and Rogers, 1982:20) to account for the diffusely mottled visual appearance of the cloth, and it is possible that a portion of these products derive from other cellulose materials and other organic substances younger than the linen itself. Finally, Raaen (1968:170) states that exchange reactions involving carbon atoms of the carboxyl group (one of the compounds produced by oxidation reactions in cellulose) can occur at temperatures of 300-400° C.

Differential firing of the charred sample might enable the intrusive carbon to be driven off in a short, low-temperature burn, and the linen structural carbon collected during a longer, higher firing, i.e. the reverse of a procedure now being developed to collect the cultural carbon from pottery. But this procedure is still experimental, and with cellulose probably untried. Except for pottery made from organic-rich clay, there are very few C14 samples which have been burnt in reducing atmosphere full of more recent carbon.

**Conclusions**

It should be abundantly clear that neither the Raes pieces nor the charred portions should be relied on for carbon-dating the relic. These serious reservations on the choice of samples to be used would, I believe, have emerged from a wide-ranging consultation with experts in the theory and practice of C14 dating. Such consultations have yet to take place; neither radiocarbon professionals (Polach, 1986, personal communication) nor archaeologists, museum personnel or other scholars who regularly make use of C14 dating in field situations have been brought into a full investigation of this "ultimate test" for the Turin Shroud.

For a unique object of such value as the Shroud, a thorough examination of all aspects of the problem would seem urgently required. As I stated in my submission to Cardinal Ballestrero, for this crucial test awaited by millions of people, it is necessary to proceed with great caution so that the eventual result is the best that science in the 1980s can produce. As Adler (1984) remarked, our aim should be "one of the best dates in the literature."

But the hour for radiocarbon has come, and we must proceed. As of this writing (April 1986), there is hope that a full round of discussions will be held. With the most sophisticated pretreatment and counting technology that can be brought to bear on the problem, and with samples from different zones of the cloth, and with the grace of God, we would in the end have radiocarbon results in good internal agreement and possibly, quite possibly, indicative of the true calendrical age of the Shroud linen.

But that is *all* we can justifiably claim. Listening to the tapes of the recent symposium at Elizabethtown, I was struck again by nearly all the speakers' repeated references to the eventual C14 date as "scientific proof of the Shroud's age" or "proof of the disauthenticity of the Shroud if it is not First Century", etc. These statements are seriously in error. We must bear in mind that C14 will not prove or disprove the Shroud's authenticity or its true age, because radiocarbon dating rests upon a number of assumptions which cannot be subjected to laboratory proof-the most important assumption in this instance being that the carbon now present in the sample is indeed the carbon present at the time the sample died (i.e., the harvest of the flax used in making the linen). As a method of dating, C14 is usually accurate, but there are exceptions. I am certain that most radiocarbon professionals would concur with the statement by Johnson *et al*. (1985:6) that:

> The existence of significant indeterminant errors can *never* be excluded from any age determination. No method is immune from giving *grossly* incorrect datings when there are non-apparent problems with the samples originating in the field. The results illustrated [in this paper] show that this situation occurs *frequently*. (emphases added).

Regardless of the C14 result, evidence from other sources would of course remain of considerable importance in the overall evaluation of the age and origin of the relic.

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