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PAPER: "THE CARBON 14 PROTOCOL"
RE: SHROUD of TURIN Carbon Dating Project.

MY FAX #:

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19 more pages to follow

Some notes regarding the preparation of the paper "The Carbon 14 Protocol": It is intended to be read by a person (or persons) who has (have) no training in the scientific field. It will be submitted to His Eminence Anastasio Cardinal Ballestrero, Archbishop of Turin and to His Holiness Pope John Paul II. My basic rule was "It must be simple but clear".

Aside from the above I have tried to follow several other rules:

1. Try to achieve a balance between discussion of the two laboratory methods of dating without "knocking" accelerator technology.

2. Accuracy is an absolute must. Although the Cardinal and the Pope may read this, it is also certain that a copy will be given to Prof. Luigi Gonella who will certainly critique any facet of the paper which is in error.

3. Try to present as broad a range of reasons as possible for the inclusion of both small counter and AMS technologies. Any additional reasons for the inclusion of both methods not mentioned here should be brought to my attention.

4. The statement should be forceful and hopefully pursuasive. But it should also be fair to all issues without seeming to "rock the boat" of any specific pursuasion on the part of the Cardinal's scientific advisor.

Any suggestions the reviewers may make which will strengthen this paper and it's intended goals will be most appreciated:

Copies sent to the following reviewers:

Rev. Albert R. Dreisbach, Jr. Director, Atlanta Internat. Center For the Contin. Stud. of the Shr. of Turin.
Dr. Harry Gove, Dept. of Physics, the University of Rochester, N.Y
Dr. Garman Harbottle, Brookhaven National Laboratory
Dr. Stewart Fleming, MASCA, The University Museum, The Univ. of PA
Dr. Robert L. Otlet, Director Radiocarbon Dating Laboratory, Harwell, Eng.
Dr. Henry Pollach, Director Radiocarbon facility, Aust. Nat. Univ. Canberra, Australia.
Dr. E. M. Scott, Dept. of Statistics, The Univ. of Glasgow, Glasgow, Scotland.

The Carbon 14 Protocol

During three days, Sept. 29-31, 1986, scientists representing two separate methods of carbon dating were brought together in a conference sponsored by the Pontifical Academy of Sciences. They developed what they believed would be the most credible method for carbon dating the Shroud of Turin: a 7-lab protocol represented by 2 small beta decay counters and 5 labs using accelerator mass spectrometry (hereafter AMS or simply "accelerator"). The outline of this protocol was recently published by Dr. Harry Gove (Gove, 1987).

Late in November newspapers revealed that the Church had rejected the 7-lab protocol in favor of only 3 labs, all of them accelerators.

More recently there has been a spate of news releases discussing the nature of these decisions. Prof. Harry Gove of the Dept. of Physics, the University of Rochester and Dr. Garman Harbottle of the Brookhaven National Laboratory, noted at a press conference (1/15/88) that the original seven lab protocol

> was carefully designed to (a) ensure a result that is scientifically rigorous, and (b) maximize the credibility of the enterprise to the public...The British Museum would encode and distribute samples, and collect and process the results...

Gove and Harbottle further explained why seven labs were involved:

> If one lab does the dating, and is in error, you will never know it. If two labs disagree, how do you know which to choose? But if six agree and one disagrees, you can surely recognize the maverick date and throw it out. That was the basis of the protocol.

The scientists noted in their release that the three laboratories which were selected expressed concern regarding the change in the protocol by stating in their joint letter to His Eminence the Cardinal Archbishop of Turin: "if only three laboratories participate, and one of them obtains a divergent, non-understandable result, the entire project could be jeopardized". They pointed out that when the results were released one or another of the groups concerned with the outcome would question those results.

Representatives of various groups with vital interest in the outcome have already begun to express their concern with the change: Fr. Adam J. Otterbein, President of the Holy Shroud Guild, made the following statement to the Chicago Tribune: "Since we have all this uncertainty, it seems to me the best possible solution at this time would be to go back to the original protocol."(Clark, 1988).

On the other hand Dr. Paul Kurtz, Chairman of the Committee for the Scientific Investigation of Claims of the Paranormal (CSICOP), sent a telegram to the seven laboratories with the following remarks:

> Many scientific investigators are disturbed that the original protocol agreed upon has been modified. The executive council of CSICOP urges you to support the original Protocol for the testing of the Shroud of Turin. It is essential that all seven of the originally selected laboratories be involved in the testing and that rigorous controls be maintained.
>
> The testing by only three laboratories would most likely be an inadequate test and may lead to ambiguous results and could bring discredit upon those involved.

Ian Anderson, writing in the British NEW SCIENTIST (1/21/88) noted that

> by eliminating Harwell and Brookhaven, the church has limited the number of techniques to be used to one, rather than two. Harwell and Brookhaven reduce the carbon in the sample to a gas, such as carbon dioxide, then count the carbon-14 decay in the gas. "The use of two techniques would have strengthened the result," said Harbottle. Teddy Hall, head of the Oxford team agrees. "Harwell would have been a good addition,"...

Pearce Wright expressed another concern in the London Times (1/16/88) about the two methods:

> The longer-established one, perfected more than 30 years ago, is known as proportional counting. The other called accelerated [sic] mass spectrometry, is less than 10 years old, and subject to some doubts over reliability.

Published reports on both sides of the Atlantic, as well as individuals and groups representing various interests, have thus expressed fears, doubts, and concerns over this change in the

protocol developed in Turin more than a year ago.

It is, however, not our purpose to dwell on the worries of the public, of religious groups, or even of scientific organizations per se, even though we are sympathetic to their position. Rather, we are concerned in this paper to explore the expressed opinions of that very group which will ultimately provide the most rigorous scrutiny of the results when they are released. We refer specifically to the scientific community comprised of the experts in the field of carbon dating and the professionals who are the users of this technique.

CARBON DATING

Before we enter into our probe of the issues we wish to say something about the nature of carbon dating itself. All living matter, as is now well known, takes in carbon during its life cycle. There are three isotopes: C-12, C-13, and C-14. The ratio of each of these differs to each other but the first two are stable isotopes and remain relatively the same throughout an organism's life--be it animal or plant. The latter isotope, C-14, is not stable, but radioactive and is constantly breaking down. But since the living organism, for example the flax plant of which the Shroud is composed, is constantly taking in C-14, representing the level of that isotope in the atmospheric reservoir, not much change occurs until that organism dies. At this point the amount of C-14 begins to diminish at a very specific rate relative to the other two isotopes. That rate is known as the "half-life" of carbon. At the 12th International Radiocarbon Conference held in Trondheim, Norway, June 1985, scientists decided to formally accept 5568 years, known also as the "Libby half-life", as the conventional basis upon which to base the ages of all carbon dated material. (Mook, 1986) By this is meant that half of all the C-14 in a dead organism is gone in 5568 years.

This constant breakdown can be detected if one places a Geiger counter near any radioactive substance. It will register as a "click" on the counter. Computers are used to count these clicks and determine by the number counted per minute just how much of the carbon is left--and thereby deduce the age of the item of interest, in this case the carbon from the Shroud sample.

Complications arise due to competition from other particles. Because of cosmic rays and even the natural radioactivity in the materials of which the carbon dating machinery may be composed

including the target on which the carbon from the Shroud sample is deposited, scientists must be concerned either with protecting the Shroud sample being dated from outside interference, by developing ways to subtract the extraneous particle counts from the counts which truly came from the Shroud sample, or by methods of manufacturing parts of the machinery to minimize the introduction of modern carbon which may interfere with determining the true date.

Moreover, scientists have learned from years of study that the reservoir of carbon was not always the same. Some years there was a heavy influx of radiation from outer space which created a greater amount of C-14 in the atmosphere. Naturally, the flax plants which grew under those conditions took in more C-14 reflecting that level. And flax which grew under conditions when C-14 was at a lower level reflected that particular environment. In order to determine just what the level of the reservoir was in each particular year scientists have carbon dated ten year or twenty year segments of tree rings and have established what is known as a "calibration curve" against which one may compare any carbon dated item to "correct" the date for that item. Although this has brought an increasing amount of precision and accuracy into the carbon dating picture scientists know that there are still very minute amounts of variation of the level of C-14 in the organism which takes it in. These tiny amounts may not be measurable by current technology except where very large samples are tested.

There is another concern which scientists keep in mind. They know that modern carbon can introduce a "false age" into the sample they are dating. The oils from hands when the Shroud was handled, the laying of flowers down on the cloth with the large amounts of pollen left there, the water thrown on the cloth to douse the fire of 1532, the "pitch" which may have come from a burning incense accidently dropped on the cloth, the sweat which dropped from St. Francis of Assisi as he examined the Shroud, the particles of paint with their traces of tempera which shower as dust from the paintings of the past, in fact, the very tempera which acted as a binder to the paint of the True Copies which were once laid down cloth-to-cloth and image-to-image on the original Shroud, all these are considered as contaminants by the scientists. Either scientists must avoid taking samples from what may be heavily contaminated areas or such contaminants must be carefully removed--some by physical cleaning, others by more rigorous chemical methods--before they can assure themselves, and the Church, of a credible date. The reason the removal of these contaminants is so important is because they could make the samples which are taken from the Shroud appear younger than they

really are.

Although I have tried to express these in lay terms the matter is far from simple. The various issues which radiocarbon scientists have faced over the years have been debated at length, proposals suggested, experiments have been run, and these in turn debated again to produce a repeating cycle of constant peer review in this highly specialized field. But that peer review has borne fruit. Beginning in the 1930s Dr. Willard F. Libby invented his low level counter and developed it to a point when, in 1946, he realized he could count the breakdown rate of C-14 and thus deduce a date for the sample of interest. Gas proportional counters were developed in the early 1950s and continued to be refined in response to problems encountered. (Arnold, 1987:424).

In 1977, Dr. Harry Gove and his associates at the University of Rochester invented the AMS technique of carbon dating. Until then the only method used was some version of what is known as "beta decay counting"--i.e. the use of a counter to count the breakdown rate. But that particular year saw the advent of a method whereby one could actually measure the amount of radiocarbon isotopes directly. Radiometry/beta decay counting had continued to develope and reigned as "king" as an outgrowth of many years of technological advancement.

Last year, Dr. James Arnold, a former colleague of Dr. Libby, could say this about the accelerator method:

> Will AMS [i.e. the accelerator method] wipe low-level counting techniques off the map? The simple answer is yes, over a wide range of long-lived cosmogenic radionuclides. For 14-C the challenge of high precision has not yet been met, though each AMS conference shows progress. Mass spectrometry [i.e. the accelerator] has historically been more precise than counting, and it will probably be so here too, someday. [Emphasis mine]. (Arnold, 1987:426).

Dr. Arnold's statement above must be set within a proper context to be appreciated. He was essentially applying it to the field of geophysics where the sample size is measured in the tens of grams. (Personal communication). Compare this with the samples requested from the Shroud where the sample size is measured in milligrams! If a scientist is cautious about accepting AMS as it currently stands in application to his own field where the sample size is substantially larger, one must then suggest that AMS, by itself, is surely not yet to that point

where high precision and pin-point accuracy is an everyday product that will produce a date for the Shroud credible to the radiocarbon scientific community.

THE RADIOCARBON SCIENTIFIC COMMUNITY AND PROFESSIONAL USERS:

SOME EXPLORATIONS INTO THEIR THOUGHTS ABOUT

THE SHROUD DATING PROJECT

A. THE RADIOCARBON SPECIALISTS:

Those who have worked at developing the gas proportional counters and the accelerators are highly respected scientists, all of them. In 1979, when the signs were clearly there that AMS would turn out to be a real competition to beta decay counting, Dr. Garman Harbottle and his associates, Drs. Edward V. Sayre, and R. W. Stoenner, invented the small gas proportional counter at Brookhaven National Laboratory. Indeed, when Dr. Robert Otlet of Harwell, England decided to come on line with small gas proportional counters, some of the basic equipment was in fact built at Brookhaven National Laboratory. (Otlet, 1986:607). As of this date both laboratories have processed a large number of archaeological samples.

From an early point Dr. Gove recognized the benefits the accelerator could have in establishing a date for the Shroud. When the secretary of the British Society for the Turin Shroud enquired regarding the application of this test Dr. Gove has worked to make his equipment available. But accelerator technology was just then brand new to the field. Therefore, it was no surprise to many when Dr. Robert Dineger and his associates developed the beginnings of what is now known as the 7-lab protocol by bringing together two of the world's authorities on the two methods specializing in the carbon dating of small samples: Dr. Garman Harbottle and Dr. Harry Gove. And it was largely due to the melding and careful weaving of both techniques, the small proportional gas counter and the accelerator, that the project for dating the Shroud gained wide acceptance among their colleagues.

Can three accelerators carbon date cloth from the Shroud? If

one talks to the specialists in the radiocarbon field one quickly learns that there are two sides to this question: a scientific one and a technological one.

I talked with Dr. Henry Pollach, director of the radiocarbon laboratory at Australian National University about this. He told me that unquestionably the accelerator could do it. In fact he explained that even if the accelerator had a pure sample as small as one half a milligram, they could do it. This is the scientific aspect.

The real challenge is to take the contaminated raw sample, clean it until it is completely free of that contamination, ensure that the equipment is calibrated with precision, guarantee that modern contamination is not intruding in some step of the laboratory process and, yes, the accelerator can do it. And the point about preventing modern carbon from intruding into the sample is particularly important for such contamination will make the Shroud appear to be younger than it actually is.

Dr. Pollach told me that in fact he did not believe the accelerator could do it even with thirty milligrams of a raw sample. (Personal communication). This is simply because the technology has not yet progressed to a point where accelerator labs have overcome the problems which cause imprecision and inaccuracy in the results. And this is compounded by the fact that there are many more steps in the treatment process, by comparison to the proportional counter, where modern carbon can intrude.

The concern Dr. Pollach expressed extended to the nature of the sample itself. He noted that the edge of a cloth, any cloth, is always more exposed to contaminants than any other area. Moreover, he pointed out that because corners are where cloth is normally picked up these would be far more contaminated. That the so-called "side-strip" side of the Shroud is probably one of the most contaminated areas due to handling can easily be shown since nearly all engravings showing exhibitions of the Shroud at least as early as the period when the Shroud was in Chanbery, France (prior to 1578) depict Church authorities holding the Shroud along that particular edge. (Moriondo & Piazza, 1978). It is therefore especially important that radiocarbon chemists address this in detail.

In 1982 a group of scientists at Glasgow University in Scotland published an international intercalibration study of 20 radiocarbon laboratories. They discovered that there were some unidentified problems either in the manner in which the results

were being reported or else in some steps in the laboratory process. The Glasgow group had selected identical tree ring samples for the 20 laboratories to date. Since the date of the tree rings had already been determined by tree ring specialists the Glasgow group knew what date to expect from the laboratories. Each lab dated at least five different samples, most as many as eight. Although most dates were "in the ball park" no two dates were identical for any single lab and no laboratory produced identical results with any other lab. (Baxter, 1983:127). They noted that "inspection of the results indicates the existance of considerable variability; for individual time points, results differ by between 316 and 724 yr, while, for individual laboratories, age differences of between 190 and 690 yr are observed." (International Study Group, 1982:620).

But since that test was not structured to identify the reasons why the differences existed, the Glasgow group decided to repeat the study on a larger scale but this time in a three stage format to attempt to discover just where the causes of the variability were. Currently, this new study is under way, this time with more than 50 radiocarbon laboratories participating. Stage one is completed and the data is analyzed. Stage two is also completed and the data is now coming in. Stage three is about to begin and all the data should be available by the end of 1988. It seems certain that this intercalibration testing will make an important contribution toward discovering some of the factors in the laboratory which contributes to what is known as "laboratory biases", factors which affect precision, accuracy, and the reporting of results. If the definitive results were available to the scientists who are currently involved in testing the Shroud perhaps some alterations in the planning might improve the chances of producing better results.

I talked with Dr. E. M. Scott, who is coordinating the Glasgow study. She has kindly supplied me with an assessment of some of the work to date: "With regard to the number of participating laboratories, both our studies (and also the BM linen study [See Burleigh, et al, 1986:571-577.]) show clearly the potential dangers of only having a small number of laboratories. For a small number of laboratories, there might well be difficulties with individual outlying observations, as well as with the problem of one or more discrepant laboratory. In the accelerator subgroup of 7 laboratories for the [current] Glasgow study, there is a range of 700 years for one sample, excluding one laboratory reduces the range to around 200 years." (Scott, 1988).

Results which are radically different from the expected target

date are called "outliers". As is now known, one of the labs in the British Museum study in preparation for the Shroud tests produced two "outliers". Clearly, both the 1982 and the current Glasgow studies indicate that outliers are more common than one might otherwise expect. Prof. Scott concludes: "The difficulty in obtaining a consensus of results across laboratories would argue having as many laboratories as feasible in the study...[at least] more than three." (Scott, 1988).

There is absolutely no doubt that accelerator technology will continue to improve. But it takes time and constant careful assessment of the situation to discover the causes of the problems and experiment with various solutions. With any highly complex system there are many things which can go wrong. One laboratory reported that they were getting imprecise and variable results because their cesium beam was out of focus (Nelson, 1986: 219). A French lab reported that it was trying to identify the source of some contamination in their system and wondered if it might be due to "backstreaming" from a turbo-pump. (Arnold & Duplessy, 1986:213). Oxford reported that a major source of error in their dating procedure was in one of their methods of pre-treatment of samples--i.e. in removing contamination. (Batten, et al, 1986:180).

B. THE PROFESSIONAL USERS:

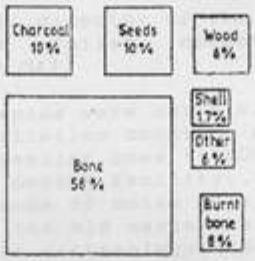
Others have raised concerns regarding a number of aspects regarding the current radiocarbon situation--particularly with accelerators and with having only three labs involved.

I talked with Dr. Stewart Fleming, Director of the Museum Applied Science Center for Archaeology (MASCA). He discussed four different points:

> 1. Dr. Fleming pointed out that all laboratories occasionally meet up with what are known as "rogue" samples. These are samples which produce strange dates that no one expected and that by all logic from the context should not have been produced. He suspected that perhaps one in ten samples handled by laboratories were "rogue samples". Whether by some quirk in the sample itself due, perhaps, to various factors in the sample's original context, or through some as yet unidentified but inadvertent intrusion of modern carbon in the laboratory situation this exposure to such unexpected results is not an uncommon occurance. In fact the Oxford Accelerator Unit reported that "At

least 1 in 5 dates are contrary to expectation." (Betten, et al, 1986).

2. Dr. Flexing notes that linen has a clear advantage with the gas counter since cloth has undergone years of testing with the conventional dating technology. On the other hand cloth does not seem to be an item which has been commonly dated by the accelerator method. For example in an article describing work done as recently as 1986 at the Oxford facility, cloth nowhere appears on the following chart: (See Betten, et al, 1986:178).



Flexing therefore feels that the employment of the small proportional counter provides an assurance of credible results whatever those results might be. In fact, he noted that he had obtained particularly good results from the Harwell, England facility. But he also emphasized that the accelerators should test some 20 to 30 samples of linen, among them being a number from the Shroud.

3. The third item he raised refers to the fact that in accelerator technology there are many more steps which the lab must go through in the process than occur with the small proportional counter. With each step in this process there is the possibility of intrusion of extraneous carbon thereby effecting the date. The use of the small proportional counter provides a very good alternate way of verifying the results obtained by the accelerator. In fact this dual method of dating has already been used by professionals as a reference point where there might otherwise have been a question of a discrepancy. A case in point is the problem of some radiocarbon dates of material from well defined historical contexts in Ancient Egypt. These discordant results which do not agree with the historical dates are off by some 350 to 450 years. Yet those who have

studied the problem in depth are able to say:

> We strongly suspect that the problem resides in the origin of the material dated. The correspondence between measurements by the accelerator mass spectrometer (AMS) and conventional methods leads us to exonerate sample treatment and radioactivity measurements. (Hassan & Robinson, 1987; [emphasis mine]).

Dr. Willy Wölfli, director of the Zurich, Switzerland facility makes a similar comment about the same situation: (Wölfli, 1987)

> ...larger samples were dated with the conventional liquid scintillation counting method at SMU Dallas, the smaller ones (< 400 mg) at the [Zurich] AMS dating facility...First of all, its [i.e., the range of dates obtained] extended tails just confirm the old maxim that 'one single date is no date' in archaeology. Secondly, the observed offset of 374 [years] of its mean value indicates some systematic errors, either in the radiocarbon dating method (note: conventional and AMS) or in the presently accepted, so called Cambridge Ancient History record, or perhaps even in both parts.

Without the two different methods there would be no way to say for certain that the current state of accelerator technology is not to blame for any discordant results. Clearly, increasing the size and/or number of samples taken from the Shroud, is only a partial answer. Dr. Wölfli says:

> For the particular case discussed here [i.e., the Egyptian dates] it is obvious that the number of 64 investigated samples is still too small to properly understand the observed disparity between radiocarbon dates and historical chronology.

Admittedly, Dr. Wölfli is discussing a chronology where a range of dates are involved. Nevertheless, if one is going to limit the number of samples from a cloth which has had an unresolved date ever since scholars began investigating it, it seems wise to seek to balance such tests with a version of conventional radiocarbon technology in order to certify the

results.

4. When dealing with cultural material scientists and historians like to achieve as great a precision as is possible. No AMS is obtaining a precision greater than about two standard deviations, ca. 70 years. Aside from this one must account for laboratory errors: when all is taken into consideration plus/minus 150 years is quite common. To this one must add a certain amount for calibration. Our concern here is that if the "window" is too large then the debate only jumps from one arena (the 14th century) to another (say, the first 4 Christian centuries). This lack of precision would not enable us to say whether it is to be dated to the early first century AD, the time of Christ, or to a few centuries later. Prof. Robert Drews, of Vanderbilt University, has suggested that the Shroud was manufactured by an early Christian group perhaps in the second or third Christian century. The greater the precision the better scholars can sort out the various possibilities.

Oxford University recently published the book ARCHAEOLOGICAL RESULTS FROM ACCELERATOR DATING: RESEARCH CONTRIBUTIONS DRAWING ON THE RADIOCARBON DATES PRODUCED BY THE OXFORD RADIOCARBON ACCELERATOR (Oxford, 1987). Prof. Robin Dennell, of the Dept. of Archaeology and Prehistory at the University of Sheffield, England, in reviewing this work, in an otherwise positive context, makes the following comment: "Before AMS is accepted as the final arbiter of chronology, criteria are needed to decide if and when an AMS date is unacceptable..." (Dennell, 1987). Removing a form of conventional radiocarbon dating and reducing the number of labs to three strips away the means of establishing whether or not the results are valid.

For all these reasons we urge that the 7-lab protocol be reconsidered.

OTHER CONCERNS

A. INFORMATION EXCHANGE.

Prof. B. S. Ottaway of the Dept. of Archaeology of the University of Edinburgh, Scotland notes that there needs to be "better information exchange between 14-C laboratories and archaeologists...and regular publication of quality controls by

all dating laboratories." (Ottaway, 1986:737).

B. SAMPLE CREDENTIALS FOR C-14 DATING

. Dr. E. M. Jope of the Queen's University of Belfast, Belfast, Northern Ireland points to another important concern. He notes that the 12th International Radiocarbon Conference was given the high-precision tree ring calibration curve. But he says:

> It must be emphasized that this high-precision calibration data can only be meaningfully applied to 14-C estimations done on sample material which has appropriately stringent (and definitive) credentials, both of context and of characteristics of sample material.

Since none of the radiocarbon laboratories will actually be permitted to be on-site when the samples are removed from the Shroud there is considerable concern that insufficient attention will be paid to the points raised by Dr. Jope.

C. BLIND TESTING.

In the printed information available there seems to be no discussion of the details as to how blind testing will be carried out. Since the Shroud's weave is a very distinctive one it goes without saying that in order to conduct the testing in as rigorous a manner as possible the cloth must be delivered to the laboratories in an unraveled condition. Without this anyone would be able to recognize immediately which sample came from the Shroud--the testing would then no longer be blind.

D. PEER REVIEW.

Science is normally conducted in the glare of peer review where other members of the scientific community study the planning and are able to offer insight into that planning. One astute observer has cogently noted: "By the very nature of Sindonology, those expert in one arena are rank neophytes in another. Nowhere is this more apparent than in the delicate dynamics of interpersonal relations and it is here that some of these peer features are found lacking." But the heavy secrecy which has cloaked much of Shroud research effort has severely hampered the peer review process. It is of major concern that the details for the radiocarbon dating of the Shroud have not been available. If we wish a rigorously executed project that will contribute toward a resolution of the controversy surrounding the Shroud such reviews and control procedures are an absolute necessity.

We believe these and the foregoing stated concerns translate into the following recommendation: That an external radiocarbon advisement committee be established and that it be composed of experts in the field of radiocarbon dating and its allied associates. We urge that there be a specialist in the field of statistics as it applies to radiocarbon dating. Dr. E. M. Scott would fit this position admirably since she is internationally recognized as the coordinator of the current International Calibration Study of Radiocarbon labs. Dr. Scott is a member of the Dept. of Statistics at the University of Glasgow, Glasgow, Scotland.

And since the chemistry of the sample is of such extreme importance we encourage the addition of chemists who have had years of experience in the carbon dating field. Two who have been suggested in my interviews with scientists in the radiocarbon community are: Dr. Willem G. Mook, Director of the radiocarbon facility at Gronnigen University in the Netherlands and Dr. Henry Pollach, Director of the radiocarbon lab at Australian National University, Canberra, Australia. These men have had 25 and 30 + years respectively in the field of archaeological/radiocarbon chemistry and could bring an immense amount of erudition to the removal of the samples from the Shroud and advisement in the pre-treatment of these samples as it relates to the context from which the samples were removed.

Because there may be special problems with the linen due to the fact that cloth has not been widely tested with the accelerator we strongly recommend that at least two textile chemists be included--one archaeologically oriented, the other with a conservational perspective. For the former an excellent choice would be Dr. Kathryn Jakes, associate director of the Center for Archaeological Science, the University of Georgia, Athens, Georgia. For the latter Dr. Jeanette M. Cardamone of Virginia Polytechnic and State University College of Textiles and Clothing would be an admirable chemist to be part this advisory group.

Finally, we suggest that several archaeologists be involved in the sample removal. Two suggestions might be Dr. Collin Renfrew of England, and William Meacham of the Hong Kong Archaeological Society.

Every effort should be made to conduct this carbon dating project with scientific rigor and with external radiocarbon peer review so that it can achieve the highest precision and accuracy given the current state of technology. It is certain that when the results are made available it will become the most closely

scrutinized carbon date in the world. To ignore peer review and professional advisement in advance of this testing is to court disaster. Hence we offer this plea for a reconsideration of the current decisions.

Samuel Pellicori of STURP once calculated that there was enough material beneath the patches to perform some 400 radiocarbon tests. It would be quite simple, comparing the x-rays taken by STURP in 1978 with color photographs, to select the patches which might have the most yellow or brown material beneath. Such a patch could be unstitched only at that place in the cloth and laid back to permit removal of the sample(s).

On the other hand, in some cases it might even be possible for certain strands of threads to be removed out from under the patches without the patches ever being unstitched. This could be done by certifying that one end of the thread is loose by examining the corresponding area in the x-ray, then snipping the thread just outside the patch and teasing it out from under the patch cloth.

CONCLUSIONS AND SUMMARY

1. We urge that the 7-lab protocol be reconsidered. It is important that more than three labs be employed. In Dr. Scott's words, "The seven lab plan has a statistical edge." Dr. Minze Stuiver similarly believes the 7-lab plan is better.
2. We urge that an advisory committee be established to:

   a. Discuss and lay out guidelines for the taking of samples.

   b. Discuss and lay out guidelines for the reporting of results.

Batter, 1983:127 =

M.S. Baxter. "An interest Tree ring replicate study" PACT Vol. 8, 1983, pp. 123-132.

2. International Study Group, 1982:620 =
" " " , "An inter-laboratory comparison of radiocarbon measurements in tree rings." Nature, Vol. 298, Aug. 12, 1982, pp. 619-623.

3. Arnold, 1987:426 =
J.R. Arnold, "Decay Counting in the age of AMS" Nuc. Instrm. & meth. in Physics Res. B29 (1987) pp. 193-195.

4. Batten, et al =
R.J. Batten, C.R. Bronk, R. Gillespie, J.A.J. Gowlett, R.E.M. Hedges, & Colin Perry, "A Review of the Operation of the Oxford Radiocarbon Accelerator Unit" RADIOCARBON, Vol. 28, 2A, 1986. pp. 177-185.

5. ~~Nelson~~ ARNOLD & DUPLESSY = (Change to Raisbeck
(M. Arnold & J.C. Duplessy
G.M. Raisbeck & Francoise Yiou
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2/2/88