

ISSUE No. 52
April 1989

A NEWSLETTER ABOUT THE HOLY SHROUD OF TURIN
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POSTER FOR THE 1931 EXPOSITION
OF THE HOLY SHROUD

EDITORIAL

In the now fortuitously fading light of that October press fanfare crying "fake" and the increasing intensity with which all the other evidence is being studied throughout the world by sindonologists fired with the spirit of objective enquiry into probably the world's greatest mystery, I believe that the historical and hence the supporting artistic and iconographic references to the Shroud have now assumed a far greater importance in the scheme of things.

There is also an increasing number of press articles being published worldwide challenging the validity of the C14 dating of 1988 from several points of view. It is good to see that reputable journals are now publishing these and even some newspapers are taking a quite sensible view of the vast evidence which contradicts the C14 findings despite their lust for a scandal-like story of a fake.

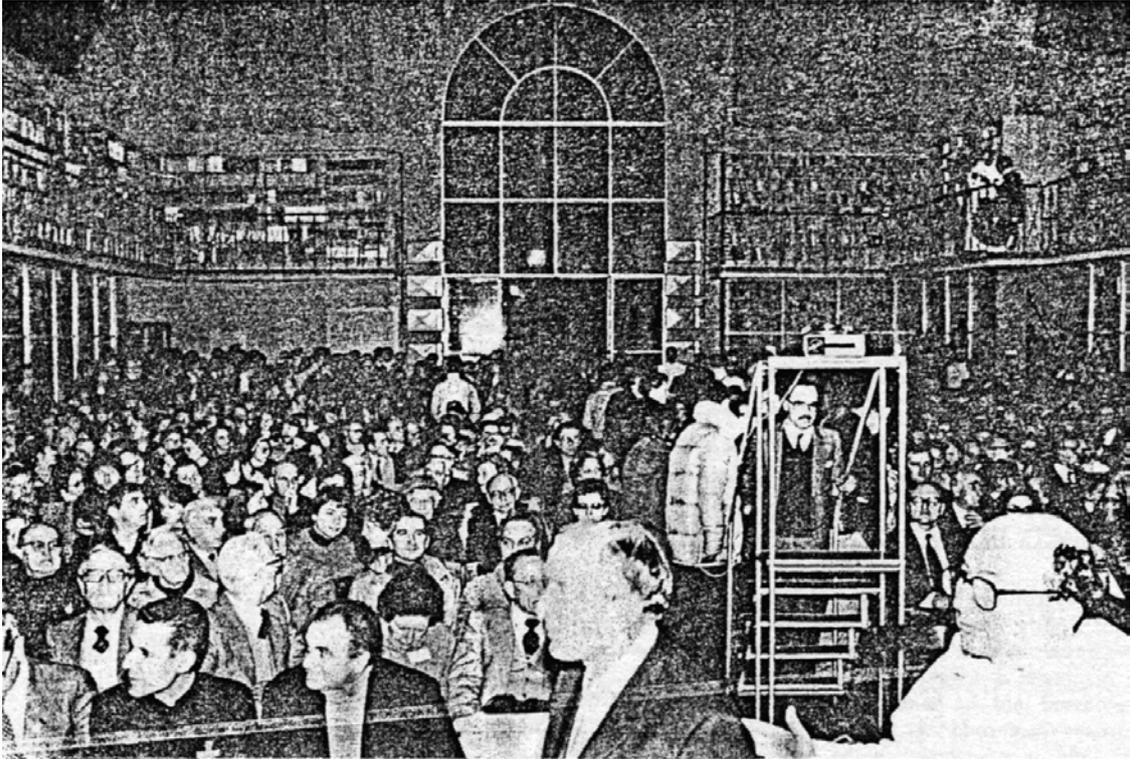
To follow my opening statement I am pleased to note that a very significant international conference has been arranged in Bologna, Italy in May of this year under the title *La Sindone E Le Icone* (The Shroud and Iconography). The programme will include papers from experts from many countries and amongst others are Ian Wilson (England), Paul Maloney and Alan Whanger (USA), Heinrich Pfeiffer and Werner Bulst (Germany), Andre Dubarle (France), Mario Moroni, Luigi Fossati, Gino Zaninotto and Giovanni Tamburelli (Italy), to mention only a few better known names in the sindonological world. I look forward hopefully to bringing *Shroud News* readers a report of the proceedings of this conference in the June issue.

There is also to be an international conference in Paris in September and whilst details are not yet in hand I have heard that Dorothy Crispino, William Meacham and Fr Peter Rinaldi will be among the speakers.

We have reproduced in full the official article reporting on the 1988 carbon 14 testing which was published in *Nature* in February this year. This will enable readers to make their own judgements and comments on the whole matter.

I have an increasing number of articles arriving in the mail which I want to bring to you and will do so as space permits in forthcoming issues. There has been a significant interest in reprints of *Shroud News* numbers 49 and 50 and I remind readers that the cost of No 50 is \$3 without postage.

REX MORGAN



The Bologna Sindonology Congress of 1981



Revd Fr Charles Foley of England
addressing the 1981 Bologna Congress

Radiocarbon dating of the Shroud of Turin

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Very small samples from the Shroud of Turin have been dated by accelerator mass spectrometry in laboratories at Arizona, Oxford and Zurich. As controls, three samples whose ages had been determined independently were also dated. The results provide conclusive evidence that the linen of the Shroud of Turin is mediaeval.

THE Shroud of Turin, which many people believe was used to wrap Christ's body, bears detailed front and back images of a man who appears to have suffered whipping and crucifixion. It was first displayed at Lirey in France in the 1350s and subsequently passed into the hands of the Dukes of Savoy. After many journeys the shroud was finally brought to Turin in 1578 where, in 1694, it was placed in the Royal Chapel of Turin Cathedral in a specially designed shrine.

Photography of the shroud by Secondo Pia in 1898 indicated that the image resembled a photographic 'negative' and represents the first modern study. Subsequently the shroud was made available for scientific examination, first in 1969 and 1973 by a committee appointed by Cardinal Michele Pellegrino¹ and then again in 1978 by the Shroud of Turin Research Project (STURP)². Even for the first investigation, there was a possibility of using radiocarbon dating to determine the age of the linen from which the shroud was woven. The size of the sample then required, however, was ~500 cm², which would clearly have resulted in an unacceptable amount of damage, and it was not until the development in the 1970s of small gas-counters and accelerator-mass-spectrometry techniques (AMS), requiring samples of only a few square centimetres, that radiocarbon dating of the shroud became a real possibility.

To confirm the feasibility of dating the shroud by these methods an intercomparison, involving four AMS and two small gas-counter radiocarbon laboratories and the dating of three known-age textile samples, was coordinated by the British Museum in 1983. The results of this intercomparison are reported and discussed by Burleigh *et al.*³.

Following this intercomparison, a meeting was held in Turin in September-October 1986 at which seven radiocarbon laboratories (five AMS and two small gas-counter) recommended a protocol for dating the shroud. In October 1987, the offers from three AMS laboratories (Arizona, Oxford and Zurich) were selected by the Archbishop of Turin, Pontifical Custodian of the shroud, acting on instructions from the Holy See, owner of the shroud. At the same time, the British Museum was invited to help in the certification of the samples provided and in the statistical analysis of the results. The procedures for taking the samples and treating the results were discussed by representatives of the three chosen laboratories at a meeting at the British Museum in January 1988 and their recommendations⁴ were subsequently approved by the Archbishop of Turin.

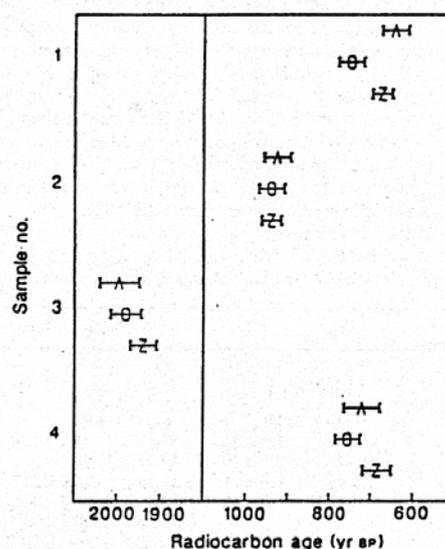


Fig. 1 Mean radiocarbon dates, with $\pm 1\sigma$ errors, of the Shroud of Turin and control samples, as supplied by the three laboratories (A, Arizona; O, Oxford; Z, Zurich) (See also Table 2.) The shroud is sample 1, and the three controls are samples 2-4. Note the break in age scale. Ages are given in yr BP (years before 1950). The age of the shroud is obtained as AD 1260-1390, with at least 95% confidence.

Removal of samples from the shroud

The sampling of the shroud took place in the Sacristy at Turin Cathedral on the morning of 21 April 1988. Among those present when the sample was cut from the shroud were Cardinal Anastasio Ballestrero (Archbishop of Turin), Professor L. Gonella (Department of Physics, Turin Polytechnic and the Archbishop's scientific adviser), two textile experts (Professor F. Testore of Department of Materials Science, Turin Polytechnic and G. Vial of Musée des Tissus and Centre International d'Etude des Textiles Anciens in Lyon), Dr M. S. Tite of the British Museum, representatives of the three radiocarbon-dating laboratories (Professor P. E. Damon, Professor D. J. Donahue, Professor E. T. Hall, Dr R. E. M. Hedges and Professor W. Woelfli) and G. Riggi, who removed the sample from the shroud.

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The shroud was separated from the backing cloth along its bottom left-hand edge and a strip (~10 mm x 70 mm) was cut from just above the place where a sample was previously removed in 1973 for examination. The strip came from a single site on the main body of the shroud away from any patches or charred areas. Three samples, each ~50 mg in weight, were prepared from this strip. The samples were then taken to the adjacent Sala Capitolare where they were wrapped in aluminium foil and subsequently sealed inside numbered stainless-steel containers by the Archbishop of Turin and Dr Tite. Samples weighing 50 mg from two of the three controls were similarly packaged. The three containers containing the shroud (to be referred to as sample 1) and two control samples (samples 2 and 3) were then handed to representatives of each of the three laboratories together with a sample of the third control (sample 4), which was in the form of threads. All these operations, except for the wrapping of the samples in foil and their placing in containers, were fully documented by video film and photography.

The laboratories were not told which container held the shroud sample. Because the distinctive three-to-one herringbone twill weave of the shroud could not be matched in the controls, however, it was possible for a laboratory to identify the shroud sample. If the samples had been unravelled or shredded rather than being given to the laboratories as whole pieces of cloth, then it would have been much more difficult, but not impossible, to distinguish the shroud sample from the controls. (With unravelled or shredded samples, pretreatment cleaning would have been more difficult and wasteful.) Because the shroud had been exposed to a wide range of potential sources of contamination and because of the uniqueness of the samples available, it was decided to abandon blind-test procedures in the interests of effective sample pretreatment. But the three laboratories undertook not to compare results until after they had been transmitted to the British Museum. Also, at two laboratories (Oxford and Zurich), after combustion to gas, the

samples were recoded so that the staff making the measurements did not know the identity of the samples.

Controls

The three control samples, the approximate ages of which were made known to the laboratories, are listed below. Two were in the form of whole pieces of cloth (samples 2 and 3) and one was in the form of threads (sample 4).

Sample 2. Linen (sample QLT/32) from a tomb excavated at Qasr Ibrim in Nubia by Professor J. M. Plumley for the Egypt Exploration Society in 1964. On the basis of the Islamic embroidered pattern and Christian ink inscription, this linen could be dated to the eleventh to twelfth centuries AD.

Sample 3. Linen from the collection of the Department of Egyptian Antiquities at the British Museum associated with an early second century AD mummy of Cleopatra from Thebes (EA6707). This linen was dated in the British Museum Research Laboratory using liquid scintillation counting, giving a radiocarbon age of 2,010 ± 80 yr BP (BM-2558). This corresponds to a calendar age, rounded to the nearest 5 years, of 110 cal BC-AD 75 cal at the 68 per cent confidence levels⁵ (where cal denotes calibrated radiocarbon dates).

Sample 4. Threads removed from the cope of St Louis d'Anjou which is held in a chapel in the Basilica of Saint-Maximin, Var, France. On the basis of the stylistic details and the historical evidence the cope could be dated at ~AD 1290-1310 (reign of King Phillippe IV).

Measurement procedures

Because it was not known to what degree dirt, smoke or other contaminants might affect the linen samples, all three laboratories subdivided the samples, and subjected the pieces to several different mechanical and chemical cleaning procedures.

All laboratories examined the textile samples microscopically to identify and remove any foreign material. The Oxford group

Table 1 Basic data (individual measurements)

	Sample 1	Sample 2	Sample 3	Sample 4	Pretreatment and replication codes
Arizona	AA-3367	AA-3368	AA-3369	AA-3370	
	A1.1b* 591 ± 30	A2.1b 922 ± 48	A3.1b 1,838 ± 47	A4.1b 724 ± 42	
	A1.2b 690 ± 35	A2.2a 986 ± 56	A3.2a (1) 2,041 ± 43	A4.2a 778 ± 88	a, method a
	A1.3a 606 ± 41	A2.3a (1) 829 ± 50	A3.3a 1,960 ± 55	A4.3a (1) 764 ± 45	b, method b
	A1.4a 701 ± 33	A2.4a (2) 996 ± 38	A3Aa(2) 1,983 ± 37	A4.4a (2) 602 ± 38	(), same subsample
		A2.5b 894 ± 37	A3.5b 2,137 ± 46	A4.5b 825 ± 44	
δ ¹³ C (‰)	-25.0	-23.0	-23.6	-25.0	
Oxford	2575	2574	2576	2589	
	O1.1u 795 ± 65	O2.1u 980 ± 55	O3.1u 1,955 ± 70	O4.2u 785 ± 50	u, unbleached
	O1.2b 730 ± 45	O2.1b 915 ± 55	O3.1b 1,975 ± 55	O4.2b(1) 710 ± 40	b, bleached
	O1.1b 745 ± 55	O2.2b† 925 ± 45	O3.2b 1,990 ± 50	O4.2b(2) 790 ± 45	(), same pretreatment/ run combination
δ ¹³ C ‡ (‰)	-27.0	-27.0	-27.0	-27.0	
ZuriCh	ETH-3883	ETH-3884	ETH-38858	ETH-3882	
	Z1.1u 733 ± 61	Z2.1u 890 ± 59	Z3.1u 1,984 ± 50	Z4.1u 739 ± 63	
	Z1.1w 722 ± 56	Z2.1w 1,036 ± 63	Z3.2w 1,886 ± 48	Z4.1w 676 ± 60	u, ultrasonic only
	Z1.1s 635 ± 57	Z2.1s 923 ± 47	Z3.2s 1,954 ± 50	Z4.1s 760 ± 66	w, weak
	Z1.2w 639 ± 45	Z2.2w 980 ± 50		Z4.2w 646 ± 49	s, strong
	Z1.2s 679 ± 51	Z2.2s 904 ± 46		Z4.2s 660 ± 46	
δ ¹³ Cl (‰)	-25.1	-23.6	-22.0	-25.5	

In years BP corrected for δ¹³C fractionation; errors at 1σ level; see text for pretreatment details.

* The identification code for each measurement shows, in order, the laboratory, sample, measurement run, pretreatment and any replication involved.

† One anomalous replicate (of 6) obtained for independent measurement O2.2b; if rejected it reduces date by 40 yr; final date quoted actually reduced by 20 yr.

‡ Measured for samples 1 and 3; assumed for samples 2 and 4.

§ The loose weave of sample Z3.1 led to its disintegration during strong and weak chemical treatments. Z3.2 was centrifuged to avoid the same loss of material.

l Average of separate determinations by AMS.

cleaned the samples using a vacuum pipette, followed by cleaning in petroleum ether (40°C for 1 h) to remove lipids and candlewax, for example. Zurich precleaned the samples in an ultrasonic bath. After these initial cleaning procedures, each laboratory split the samples for further treatment. The Arizona group split each sample into four subsamples. One pair of subsamples from each textile was treated with dilute HCl, dilute NaOH and again in acid, with rinsing in between (method a). The second pair of subsamples was treated with a commercial detergent (1.5% SDS), distilled water, 0.1% HCl and another detergent (1.5% triton X-100); they were then submitted to a Soxhlet extraction with ethanol for 60 min and washed with distilled water at 70°C in an ultrasonic bath (method b).

The Oxford group divided the precleaned samples into three. Each subsample was treated with 1M HCl (80°C for 2 h), 1M NaOH (80°C for 2 h) and again in acid, with rinsing in between. Two of the three samples were then bleached in NaOCl (2.5% at pH-3 for 30 min).

The Zurich group first split each ultrasonically cleaned sample in half, with the treatment of the second set of samples being deferred until the radiocarbon measurements on the first set had been completed. The first set of samples was further subdivided into three portions. One-third received no further treatment, one-third was submitted to a weak treatment with 0.5% HCl (room temperature), 0.25% NaOH (room temperature) and again in acid, with rinsing in between. The final third was given a strong treatment, using the same procedure except that hot (80 °C) 5% HCl and 2.5% NaOH were used. After the first set of measurements revealed no evidence of contamination, the second set was split into two portions, to which the weak and strong chemical treatments were applied.

All of the groups combusted the cleaned textile subsample with copper oxide in sealed tubes, then converted the resulting CO₂ to graphite targets. Arizona and Oxford converted CO₂ to CO in the presence of zinc, followed by iron-catalysed reduction to graphite, as described in Slota *et al.*⁶. Zurich used cobalt-catalysed reduction in the presence of hydrogen, as described by Vogel *et al.*^{7,8}.

Each laboratory measured the graphite targets made from the textile samples, together with appropriate standards and blanks, as a group (a run). Each laboratory performed between three and five independent measurements for each textile sample which were carried out over a time period of about one month. The results of these independent measurements (Table 1) in each case represent the average of several replicate measurements made during each run (samples are measured sequentially, the sequence being repeated several times). The specific measurement procedures for each laboratory are given by Linick *et al.*⁹ for Arizona, by Gillespie *et al.*¹⁰ for Oxford and by Suter *et al.*¹¹ for Zurich. Arizona and Oxford measured ¹⁴C/¹³C ratios by AMS and determined the ¹³C/¹²C ratios using conventional mass spectrometry. Zurich determined both ¹⁴C/¹²C and ¹³C/¹²C quasi-simultaneously using AMS only.

The conventional radiocarbon ages were all calculated using the procedures suggested by Stuiver and Polach¹², with normalization to δ¹³C = -25‰, and were accordingly reported in yr BP (years before 1950). The errors, which are quoted in Table 1 at the 1σ level (σ is standard deviation), include the statistical (counting) error, the scatter of results for standards and blanks, and the uncertainty in the δ¹³C determination (Arizona includes the δ¹³C error at a later stage, when combining subsample results; Oxford errors below 40 yr are rounded up to 40).

Results

On completion of their measurements, the laboratories forwarded their results to the British Museum Research Laboratory for statistical analysis. The individual results as supplied by the

laboratories are given in Table 1. Each date represents a unique combination of pretreatment and measurement run and applies

Table 2 Summary of mean radiocarbon dates and assessment of interlaboratory scatter

Sample	1	2	3	4
Arizona	646±31	927±32	1,995±46	722±43
Oxford	750±30	940±30	1,980±35	755±30
Zurich	676±24	941±23	1,940±30	685±34
Unweighted mean*	691±31	936±5	1,972±16	721±20
Weighted mean [†]	689±16	937±16	1,964±20	724±20
χ ² value (2 d.f.)	6.4	0.1	13	2.4
Significance [‡] level (%)	5	90	50	30

Dates are in yr BP. d.f., degrees of freedom.

* Standard errors based on scatter.

† Standard errors based on combined quoted errors.

‡ The probability of obtaining, by chance, a scatter among the three dates as high as that observed, under the assumption that the quoted errors reflect all sources of random variation.

to a separate subsample, except where indicated by the identification code. From these data it can be seen that, for each laboratory, there are no significant differences between the results obtained with the different cleaning procedures that each used.

The mean radiocarbon dates and associated uncertainties for the four samples, as supplied by each of the three laboratories, are listed in Table 2 and shown in Fig. 1. Also included in Table 2 are the overall unweighted and weighted means, the weights being proportional to the inverse squared errors as quoted by the laboratories. The underlying principle of the statistical analysis has been to assume that, unless there is strong evidence otherwise, the quoted errors fully reflect all sources of error and that weighted means are therefore appropriate. An initial inspection of Table 2 shows that the agreement among the three laboratories for samples 2, 3 and 4 is exceptionally good. The spread of the measurements for sample 1 is somewhat greater than would be expected from the errors quoted.

More quantitatively, to establish whether the scatter among the three laboratory means was consistent with their quoted errors, a χ² test was applied to the dates for each sample, in accordance with the recommended procedure of Ward and Wilson¹³. The results of this test, given in Table 2, show that it is unlikely that the errors quoted by the laboratories for sample 1 fully reflect the overall scatter. The errors might still reflect the uncertainties in the three dates relative to one another, but in the absence of direct evidence on this, it was decided to give the three dates for sample 1 equal weight in determining the final mean, and to estimate the uncertainty in that mean from the scatter of results.

As shown in Table 2, the unweighted mean of the radiocarbon age of sample 1 and its uncertainty are 691 ±31 yr BP. The confidence limits for sample 1 were obtained by multiplying the uncertainty by *t_d*, the value of a Student's *t* distribution with *d* degrees of freedom at the appropriate probability level. The value of *d*, which lies between the inter- and intra-laboratory degrees of freedom—that is, between 2 and 9—was estimated at 5 on the basis of an analysis of variance on the 12 individual measurements supplied by the laboratories¹⁴. Individual measurements from a particular laboratory were weighted according to their inverse squared errors, but the contributions from different laboratories were weighted equally, thus ensuring consistency with Table 2. Thus for sample 1, where the error has been estimated from the scatter, ~63% and 95% confidence limits for the true radiocarbon date were found from the 1.1σ and 2.6σ errors about the unweighted mean respectively, the multiplying factors being obtained from standard tables of the *t₅* distribution. However, for samples 2, 3 and 4, the limits were obtained in the usual way from 1σ and 2σ quoted errors about the weighted means, assuming normality.

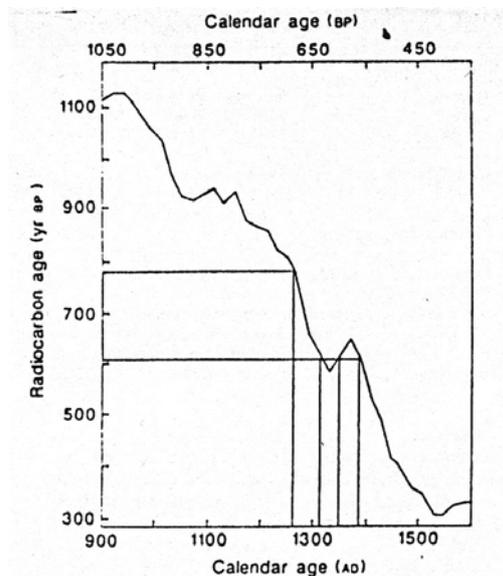


Fig. 2 Calibration of the overall mean radiocarbon date for sample 1 (the Shroud of Turin) using the 'intercept' method. (See also Table 3.) Calibration is necessary because of natural variations in atmospheric ^{14}C . The calibration curve for the relevant period is that of Stuiver and Pearson⁵, a portion of which is illustrated. The uncertainty in the calibration curve has been combined with the error in the mean radiocarbon date, giving the 95% confidence limits on the radiocarbon scale; the error envelope on the curve has therefore been omitted from the diagram. The stippled areas show how the 95% confidence limits are transformed from the radiocarbon to the calendar scale.

The calendar-age ranges which correspond to the radiocarbon confidence limits are shown in Table 3. These were determined from the high-precision curve of Stuiver and Pearson⁵ based on dendrochronological dating. Method A (the intercept method) in revision 2.0 of the University of Washington Quaternary Isotope Laboratory Radiocarbon Calibration Program¹⁵ was used. In this method, the error in the calibration curve is first incorporated into the radiocarbon error, thus widening the limits on the radiocarbon scale slightly; calendar ages are then found that correspond to these limits, without transforming the complete probability distribution of radiocarbon dates. No additional uncertainty has been added to take account of the short growth period of textile samples. There is little published guidance on this, although it has been suggested that 15 years should be added in quadrature to the overall uncertainty in the radiocarbon date for samples of growth period less than one year, such as linen. In general, such additional uncertainty would widen the 95% calendar limits by ~2-4 years at either end, except for sample 3 where the 9 cal BC limit would be changed to 34 cal BC.

The 95% limits for the shroud are also illustrated in Fig. 2, where it is apparent that the calibration of the radiocarbon date for sample 1 gives a double range. The correct transformation of probability distributions from the radiocarbon to the calendar scale is still subject to debate, there being two different methods of dealing with multiple intercepts. However, both methods agree that the major probability peak lies in the earlier of the two ranges, in the 68% range at the end of the thirteenth century. Sample 4 has a very narrow calendar range: this is due to the steep slope in the calibration curve at this point, and is an occasional instance of calibration reducing rather than increasing a

Table 3 Calibrated date ranges at the 68% and 93% confidence levels

Sample	Mean date		Calendar date ranges	
	(yr BP)			
1*	691±531	68%	AD 1273-1288	
		95%	AD 1262-1312, 1353-1384 cal	
2†	937±16	68%	AD 1032-1048, 1089-1119, 1142-1154 cal	
		95%	AD 1026-1160 cal	
3‡	1,964 ±20‡	68%	AD 11-64 cal	
		95%	9 cal BC-AD 78 cal	
4‡	724±20	68%	AD 1268-1278 cal	
		93%	AD 1263-1283 cal	

* Confidence limits on the radiocarbon scale found from the standard error on the unweighted mean, assuming a t_s distribution (multiplying factors 1.1 and 2.6 for 68% and 95% limits respectively). Standard error estimated from scatter.

† Confidence limits on the radiocarbon scale found from the standard error on the weighted mean, assuming a normal distribution (multiplying factors 1 and 2 for 68% and 95% limits respectively). Standard error computed from quoted errors.

‡ Date by conventional radiocarbon dating at the British Museum: 2010 ± 80 yr at BP (BM - 2558).

confidence range. Sample 3 compares well with the date obtained by conventional radiocarbon dating; there is no evidence for a difference between the two results. The dates for samples 2 and 4 agree with the historical evidence, which places them in the eleventh to twelfth centuries and late thirteenth/early fourteenth centuries AD respectively.

The results, together with the statistical assessment of the data prepared in the British Museum, were forwarded to Professor Bray of the Istituto di Metrologia 'G. Colaninetti', Turin, for his comments. He confirmed that the results of the three laboratories were mutually compatible, and that, on the evidence submitted, none of the mean results was questionable.

Conclusions

The results of radiocarbon measurements at Arizona, Oxford and Zurich yield a calibrated calendar age range with at least 95% confidence for the linen of the Shroud of Turin of AD 1260-1390 (rounded down/up to nearest 10 yr). These results therefore provide conclusive evidence that the linen of the Shroud of Turin is mediaeval.

The results of radiocarbon measurements from the three laboratories on four textile samples, a total of twelve data sets, show that none of the measurements differs from its appropriate mean value by more than two standard deviations. The results for the three control samples agree well with previous radiocarbon measurements and/or historical dates.

We thank Cardinal Anastasio Ballestrero for allowing us access to the shroud, Professor L. Gonella for his help and support throughout the project and Professor A. Bray for commenting on our statistical assessment of the data. We also thank Miss E. Crowfoot, T. G. H. James, Dr J. Evin, M. Prevost-Macillacy, G. Vial, the Mayor of Saint-Maximin and the Egypt Exploration Society for assistance in obtaining the three known-age control samples. Oxford thank P. H. South (Precision Processes (Textiles) Ltd, Derby) for examining and identifying the cotton found on the shroud sample; R. L. Otlet (Isotopes Measurement Laboratory, AERE, Harwell) for stable isotope ratio measurements on two samples; J. Henderson and the Department of Geology, Oxford Polytechnic for undertaking scanning electron microscopy, and SERC for the Special Research Grant which provided the primary support for the Radiocarbon Accelerator Unit. Zurich thank the Paul Scherrer Institut (PSI, CH-5234 Villigen) for technical and financial support. The AMS Programme at Arizona is partially supported by a grant from the NSF.

Received 5 December 1988; accepted 18 January 1989.

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Shroud irradiated with neutrons?

Sir - If the shroud of Turin is in fact the burial cloth of Christ, contrary to its recent carbon-dated age of about 670 years (*Nature* 335, 663; 1988 and 337, 611; 1989), then according to the Bible it was present at a unique physical event: the resurrection of a dead body. Unfortunately, this event is not accessible to direct scientific scrutiny, but the image on the shroud, which still cannot be duplicated, appears to be a scorch, indicating that the body radiated light and/or heat. It may also have radiated neutrons, which would have irradiated the shroud and changed some of the nuclei to different isotopes by neutron capture. In particular, some ^{14}C could have been generated from ^{13}C . If we assume that the shroud is 1,950 years old and that the neutrons were emitted thermally, then an integrated flux of 2×10^{16} neutrons cm^{-2} would have converted enough ^{13}C to ^{14}C to give an apparent carbon-dated age of 670 years.

This flux of neutrons should have other measurable consequences. The neutron irradiation would probably not have been uniform, for example, so the $^{14}\text{C}/^{13}\text{C}$ ratio should vary in different parts of the shroud. In addition, other unstable isotopes should have been formed. Several of these isotopes have half-lives long enough that they would still be present, yet short enough that they are not found naturally.

The unstable isotopes most likely to be found in the shroud are ^{36}Cl and ^{41}Ca . The presence of either would confirm that the shroud had been irradiated with neutrons. An accurate measurement of the ratio of either ^{36}Cl to ^{35}Cl or ^{41}Ca to ^{40}Ca (see table) would test the prediction of an integrated neutron flux of 2×10^{16} neutrons cm^{-2} .

This may not be possible, however, because contamination with new sources of chlorine or calcium may have occurred from washings or other sources since the irradiation took place.

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HEDGES REPLIES-The processes suggested by Phillips were considered by the participating laboratories. However, for the reasons given below, the likelihood that they influenced the date in the way proposed is in my view so exceedingly remote that it beggars scientific credulity.

(1) No plausible physical mechanism has been proposed to explain how the resurrection was accompanied by a significant neutron flux. If a supernatural explanation is to be proposed, it seems pointless to make any scientific measurement on the shroud at all.

(2) Assuming a 'scientific' (but not yet articulated) explanation for the neutron flux, it is an amazing coincidence that the neutron dose should be so exactly appropriate to give the most likely date on historical grounds. (Arguably a total of 10^{28} neutrons (the number in a human body) would be available. Using Phillips' figures, this would be sufficient to impart a date of 100,000 years into the future. To produce a date within 100 years of the first recorded history of the shroud implies that the dose has been 'fine-tuned' to better than one part in a hundred million.)

(3) In fact, the dose proposed by Phillips is much too high, as he has not included the neutron capture by nitrogen in the cloth. A

not untypical N content in linen is 1,000 p.p.m., for which a thermal neutron flux of 2×10^{13} cm^{-2} (that is, 1,000 times less) would be appropriate. This does not change the basic argument, but changes the chemical implications (even without recoil effects). The three dating laboratories used different types of chemical pre-treatments, (for example at Oxford we purified the cellulose), yet obtained equivalent results. This shows that any ^{14}C formed by neutron irradiation behaves chemically in the same way as the original ^{14}C . This is inherently unlikely because the original nitrogen is in a chemically quite different environment.

(4) As Phillips comments, one might expect that the 'irradiation' would be nonuniform. The three samples were contiguous, but at least on a local scale of 10 mm, any such variation was less than 1 per cent.

The lower neutron flux would reduce the conversion of ^{36}Cl to ^{35}Cl , but should still give a ratio significantly above background (if there has been no loss or gain of Cl since). Electron spin resonance signals from the 'irradiation' might also persist. However, such measurements are unlikely to confirm the presence or absence of neutron irradiation with absolute certainty. This, I fear, will not be achieved in a finite number of tests. If we accept a scientific result, we must exercise a critical notion of the probabilities involved. If we demand absolute certainty, we shall have to rely on faith.

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Properties of selected parent/daughter isotopes					
Parent isotope	Natural abundance (per cent)	Neutron capture cross-section (barns)	Daughter isotope	Half-life (years)	Predicted parent/daughter ratio
^{13}C	1.11	0.0009	^{14}C	5.730	1.2×10^{-10}
^{35}Cl	75.77	43	^{36}Cl	3.0×10^5	8×10^{-7}
^{40}Ca	96.94	0.40	^{41}Ca	1.0×10^5	8×10^{-9}

Predicted parent/daughter ratios (right-hand column) are for a new cloth irradiated with 2×10^{16} neutrons cm^{-2} . For $^{14}\text{C}/^{13}\text{C}$ the ratio is about 17 per cent higher than normal.

LIMITS OF THE RADIOCARBON ANALYSIS CARRIED OUT ON THE HOLY SHROUD MATERIAL

by Don LUIGI FOSSATI, Turin, Italy (Translated by HELEN FERRIS, Sydney)

The many and vociferous claims that the Holy Shroud is a fake because it is a product of the medieval period may have disturbed those who have always regarded the Shroud preserved in Turin as the most important record and long-standing relic of the Passion, Death and Resurrection of Our Lord.

The approximate dating of the radio carbon analysis which states the origin of the material to be between the years 1260 and 1390 is only one piece in the complicated and mysterious mosaic which is the Shroud.

It would be too simplistic to declare that technology has supplied its results, therefore the Shroud is not authentic. How simplistic likewise would it be to affirm that the Shroud is authentic for the reason that the dating by technology is inaccurate.

The problem is extremely complicated and requires a complex evaluation of the many facets that it presents.

Having sealed the tomb and posted guards on watch, the Sanhedrin believed it had brought an end to the story of Jesus of Nazareth. But it was not so because, with the Resurrection, there then dawned a new era which took its name from Him: the Christian era.

Similarly the announcement that the material of the Shroud dates from the Middle Ages should not be taken as the conclusion of research about which there is no more to say, but as an intermediate stage which will stimulate further research. Desiring as we continually do the revelation of new truths, it is arduous and difficult to fuse them together.

Welcomed with admiring surprise the announcement has resulted in various expressions of disappointment pronounced side by side with renewed interest in the question, so many and so diverse are the contradictory aspects which prevent the announcement from being accepted without the slightest doubt unless all else can be proved to be incorrect.

Thus commences a new phase of study to complement those conducted during the last ten years, from which stemmed those great initiatives after the reproduction of the first photographs which had shown that the features visible on the Shroud are a perfect negative reversed to positive on the photographic plate when developed, the first step in the photographic process: a positive-negative with the inversion of "chiaroscuro", i.e. a negative photographic reproduction of the reality.

LIMITS OF THE RADIOCARBON ANALYSIS (cont'd)

Suddenly to present as sole evidence the dating of the material does not invalidate the Shroud's authenticity which may be traced to other origins from the premise that no other explanation has been discovered relative to the origin of the imprints, however faint, however evanescent, so that they can disappear from the sight of someone looking very closely at the Shroud.

It may therefore occur that some aspects of the radiocarbon process are re-assessed to give a clearer result without dealing with the technical problems inherent in the process.

Sooner or later we would have arrived at radiocarbon analysis. And since the fifties what a number of theories has been advanced. But in those days it was useless to pay attention owing to the appropriate quantity of material which had to be burnt to obtain the pure carbon necessary for the test. With the passing of years the method has been perfected and, as in other cases, the amount of material to be destroyed has been reduced to milligrams. Nevertheless absolute precision has not been reached, for example during the years of division about radio activity. Furthermore the final date is always contained in a range which operates over 200 to 300 years.

In spite of its advantages and limits, people are not convinced, as far as is known, by the expected finalizing experiments in this specific case, and not even by an accurate study of the real thing -- the Shroud as it appears today after the numerous changes of the past.

The result has therefore been an experiment in this area similar to blind man's buff; the threads of material of other origin which could easily be identified have not been examined for the characteristics of the Shroud material.

But it is a simple matter to criticize. Without wishing to be a prophet I refer to what I wrote in 1955 in an article published by the *Osservatore Romano* (26th June) under the title of: "Radio Carbon Analysis for the Shroud of Turin."

"Concerning the eventual experiments which fittingly will be conducted on the Shroud to act as a check on the inevitable errors of the radio carbon procedure." Interference with the Shroud as follows:

1. Carbonized sections of cloth consequent on the fire at Chambery (1532)
2. The fabric onto which the Shroud is now stitched and the repairs done by the Poor Clare Sisters (1534)
3. Tiny traces of a second fire not recorded historically.
4. Mending done by the Blessed Sebastian Volfre (1694)
5. Additionally, two other patches of unknown date.

LIMITS OF THE RADIOCARBON ANALYSIS (cont'd)

And here is a point which must be made with regard to the development of the analysis: the fact was not taken into consideration that the Shroud namely consists of two cloths of equal size, one (the Shroud) sewn onto the other (the supporting cloth). No one has said anything about this connecting of the one with the other.

Hence, analysis of the Shroud material, plus analysis of the protective material which from 1534 onwards acted as reinforcement to the Shroud damaged by the Chambery fire of 1532. And moreover analysis of two threads of the two cloths together in order to observe the results and to confront the differences seeing that after that date they were in constant contact rolled onto the cylinder used to preserve the Shroud.

A reciprocal contamination certainly took place because in 1534 the two cloths were notably different: that devastating fire fused significantly the cloth itself and the protective material.

This supposition was confirmed recently by a notice which appeared in the journals (*Confronting Integration: Our Times*, 4th December 1988, p 7). In 1982 a radiocarbon analysis was conducted, not authoritative because not officially recognised, but carried out secretly on one thread of Shroud material removed in 1973 in the course of a textile examination attributed to Professor Gilbert Raes of the Textile Institute in Ghent. This analysis, described in newspaper reports, yielded two different datings: one 200 years AD and the other 1000 years AD. Agreement has eluded the experimenters, also consideration was given, let us hope, to many other circumstances which caused soiling, a number of which may have influenced the findings more than a little.

Was the Shroud really boiled in oil? Has it been cast onto a fire? Or was it washed in detergents as has been said?

Although affirmative reports have been made by the chronicler Antoine Lalaing who participated in an exposition of the Shroud at Bourg-en-Bresse on 14th April 1503, it would be difficult to be sure that such tests were ever applied; if on the other hand the tests genuinely took place, they would guarantee the truth of the findings without any need to resort to further tests.

Over and above these essential precautions indispensable to a sound case, many others were definitely taken into account as is usual in any dating. Nevertheless when considering everything objectively, the result does not appear convincing.

Other aspects of the whole affair are not so straightforward. Why indeed was communication not effected by the co-ordinator of the work, Professor Michael Tite, but instead by the Archbishop of Turin, Cardinal Anastasio Ballestrero? It has

LIMITS OF THE RADIOCARBON ANALYSIS (cont'd)

been declared that this was an inexcusable ploy by the three laboratories, Why were there not admitted during the analyses representatives of the owners, that is to say, the Holy See or the Turin Curia while the three heads of the three laboratories chose to be present at the removal of the samples?

Furthermore how does one explain the prolonged delay of the official scientific reports which, to preserve proper chronology, ought to have been published simultaneously with the final communiqué or very shortly afterwards in view of various anticipatory and reckless indiscretions about the mediaeval dating of the "fake" shroud?

The pictorial origin of the image has been repeatedly ruled out. On the Shroud one cannot find an accretion of foreign matter, there is not the slightest trace of colouring of any kind, nor does it portray any style commensurate with a particular school or period. What one sees is a pure and simple depiction of reality, revealed only after being photographed because the Shroud projects a negative image not discernible or appreciated by the eye accustomed to the solid reality of things.

The image is formed of microscopic dots which are the microfibrils of cellulose slightly modified by a process which can be no better defined than dehydration-oxidation. These dots, or more accurately, these fibrils yellowed by cellulose at a short distance from them, together with the warp and weft of the weave cannot be of the date of origin defined by the three-dimensional code applied by electronic means.

It is likely that the phenomenon could not be verified on a perfectly smooth surface, and if the image was not broken but uniformly smooth and straight.

The accidental traces of colouring which chance to be found at a few places on the cloth are due to the reproductions which have been made in the past - prior to their being presented to this or that personage. Indeed they were measured by contact with the original, perfectly stretched over it to become, according to belief, other relics. As with pictures they left fresh traces of paint. This fact is documented in the writings of the time as well as on the reproductions themselves accompanied by the date.

The imprints of the body together with the resulting spots of blood and of sweat were produced contemporaneously; furthermore the blood soaking into the threads of the cloth resulted in their pre-dating the main imprint. When the fibrils of the cellulose of the linen are separated they do not change beneath the spots of blood.

LIMITS OF THE RADIOCARBON ANALYSIS (cont'd)

The observations exclude a heated chalk sketch as origin, as maintained by some scholars who were unable to obtain simultaneously the imprint of the face and the colour of the blood traced in one second's time on a model.

If a more or less distant future sees with absolute certainty the confirmation of the Shroud as being made of material of mediaeval origin, and at the same time, it remains impossible to explain by natural methods the origin of the imprints, a different process of reasoning will be essential.

Those who believe in the supernatural will be able to reflect on a miraculous event which occurred in the Middle Ages, (according to the dating) and which through God's goodness enabled believers to be strengthened and re-invigorated in their faith, in their hope and in their love towards His dearly beloved Son who died and rose again for our redemption.

Also in this connection it is necessary to speak of the authenticity of the form seen on the Shroud because God who is perfect Truth did not create this miracle to represent the outward signs of His Son's Passion, but as can be seen, to present the features and the appearance of His perfect Humanity.

One can therefore have a tranquil belief in the authenticity of the Shroud not as an act of faith but by means of reasoned and logical conviction.

On a theoretical basis this solution may be accepted even though it may never be possible to prove it. But who can fathom the mysteries of God?

Diversely:

- Who is this man scourged as Christ was?
- Who is this man crucified as Christ was?
- Who is this man pierced through the heart as Christ was?
- Who is this man wrapped in a Shroud as Christ is said to have been?
- Who is this man with closed eyes but with a penetrating look as is said of Christ?
- Who is this man depicted by means of a technique which we do not know how to explain?
- Who is this man whose negative imprints have remained inexplicable for so many centuries?
- Who is this man who appears to us through the photographic process in the completeness of His personality and in the beauty of His pictured face?

He may simply be a religious symbol or, no less likely, the true image of Christ who has forever revealed Himself as the Way, the Truth and the Life.

In this case the Shroud would not be a relic in the true sense of the word and according to universal understanding of the term, but an authentic record inasmuch

LIMITS OF THE RADIOCARBON ANALYSIS (cont'd)

as it places before us the re-creation of an event which happened at a particular time but is still ever-present and transmitted through technical progress by means of symbols it has become possible to decipher.

In the first case (Christ's burial Shroud) as in the second (a miraculous event) the Shroud would be authentic, most of all in the second case because God cannot deceive and if those imprints depict the Passion as endured by Christ, we have actually before our eyes the reality of His Humanity unexpectedly revealed through photography.

And, in fact, it should be noted that on the negative of Avv. Secondo Pia in 1898 there appeared after centuries the wonderful face as a positive image, the face of Christ composed in the sepulchre awaiting the Resurrection.

On the opposite page is a new reproduction of the face of the man in the Shroud as developed by Professor Giovanni Tamburelli of Turin. We have referred to his work in previous issues of *Shroud News*. Tamburelli and his colleagues have, over a number of years, refined the VP8 Image Analyzer work originally done by Jumper and Jackson which produced the first three-dimensional pictures from the Shroud image. Tamburelli uses a process of electronic "cleaning" of the image to create eventually a computer produced likeness of the man whose face made the image. This is regarded as the most accurate possible scientific re-creation of the features of the man in the cloth and is done without any use of artistic imagination. We are indebted to Harold Nelson, Editor of *Torch* for this picture.



OFFICIAL ANNOUNCEMENT FROM THE INTERNATIONAL CENTRE OF SINDONOLOGY

On November 5th 1988 a meeting was held at the International Centre of Sindonology (which had been announced at the conclusion of the 4th National Congress of Sindonology that was held in Syracuse on October 17th-18th 1987). Present at the meeting were the members of the Steering Committee of the Centre, the representatives of the Regional Delegations and of the Italian Groups of the Centre, together with some sindonologists from several regions of Italy.

The meeting was preceded by the celebration of a mass said for the soul of the late lamented Prof Don Piero Coero Borga (1924 - 1986), who had been the Secretary of the Centre for over thirty years.

At the end of the meeting a press conference was held which was attended by a large number of journalists representing some of the most important agencies, newspapers and broadcasters.

Cardinal Anastasio Ballestrero, Archbishop of Turin and Papal Custodian of the Shroud sent his blessing to all those present.

The meeting, which had originally been planned for a general examination of the study and research programmes of the Centre, was in practice devoted largely to a detailed and thorough examination of the results of the carbon 14 dating test which had been carried out on a sample of cloth taken from the Shroud on April 21st 1988, and also to a careful evaluation of the deductions that could be made from these results which were released officially on October 13th 1988.

The main conclusions that emerged from the extensive debate were the following:

1. A scientific evaluation of the dating test is not yet possible as the reports of the three laboratories which were entrusted with the task of carrying out the carbon dating and which should have been consigned to Dr Michael Tite of the British Museum, co-ordinator of the project, and therefore also to Cardinal Ballestrero, have not yet been rendered public. Moreover the promised scientific text has not yet been published. The experts present at the meeting have however underlined the inherent limits characteristic of the carbon 14 dating method.
2. Criticism was levelled at the incorrect behaviour of the three laboratories. The presence of their representatives at the operation of taking the samples and the fact that the Shroud cloth was easily recognisable with respect to the control samples of known age that were given to the three laboratories (this fact had been explicitly admitted even by Dr Tite) had removed any scientific value from the so-called "blind procedure", which had been planned as a guarantee of reliability and impartiality.
3. It does not seem that the techniques of "cleaning" the fragments of cloth analysed are sufficient if the polluting biological material that has been deposited

OFFICIAL ANNOUNCEMENT (cont'd)

on the Shroud over the centuries is taken into account: pollen, hyphae, spores, residues of carbonised wood conveyed by the water used to put out the fire of Chambery in 1532, residues of the prolonged and repeated exposure to candle smoke in surroundings which were rich in carbon dioxide, organic residues due to the handling undergone by the cloth and which were obviously present to a greater extent along the edges of the cloth itself, residues due to the presumed "boiling in oil and exposure to fire" narrated by Antoine de Lalaing on what took place at Bourg-en-Bresse in 1503, etc. Through appropriate experiments an indicative evaluation of the quantity of carbon that can have polluted the Shroud as a consequence of these events will be made and this evaluation will be used to determine theoretically the extent of any possible error in the dating.

4. Some alternative dating methods were considered. They will be subject to a thorough analysis both theoretical, through a careful evaluation of the reliability and precision of such methods, and experimental, through a series of dating tests on trial samples.

5. Some research programmes were explained and some proposals were made for tests of biochemical nature aimed at deepening and defining studies that have been carried out during the last decade and moreover, indirectly, at permitting a more realistic evaluation of the hypothesis of a mediaeval origin of the Shroud.

6. Some historical studies were proposed relative both to the period in which the C 14 dating test has placed the Shroud and to the preceding period. The research programme on the reliability of the testimony of Antoine le Lalaing about the "trial" that the Shroud is said to have undergone in 1503 is particularly interesting.

7. A detailed photographic research was proposed in order to supply scientists with photographs with highly specific characteristics and which are destined for precise research programmes, such as, for example, an accurate survey, which would also be carried out using electronic processing, on the peculiarities of eventual marks left by the coins which were placed on the eyelids and on the writings which have been identified in various places on the Shroud.

8. The absolute necessity of developing an extensive multidisciplinary research was underlined, so as to permit a comparison of data deriving from research and experiments in different fields. Only a comparison of these data can lead to a serious and reliable verification of all the results which have been obtained in the recent and distant past and also of those which it is hoped may be obtained in the future. The absence of such interdisciplinary research in the recent C 14 dating test was one of the causes of the very contrasting evaluations which were made on the results of this analysis.

OFFICIAL ANNOUNCEMENT (cont'd)

9. For this reason it was decided to compile in a very short time a detailed, systematic and interdisciplinary research programme by the scientists of the Centre.

10. The dates for the next two meetings organised by the Centre were announced. The first will be held in Bologna in April 1989 on the theme "The Shroud and Iconography"(1). Subsequently the 5th National Congress of Sindonology will be held in Cagliari in April 1990 on the theme "The dating of the Shroud", and also the 2nd National Competition of Figurative Arts inspired by the Shroud (2).

11. Finally, the recommencement of publication of the journal *Sindon* was announced. This journal has been the official organ of the Centre since 1959. The first number of the new series is expected to be published at the beginning of 1989.

At the conclusion of the meeting telegrams, the texts of which are quoted separately, were sent to His Holiness John Paul II and to Cardinal Ballestrero.

(1) Person in charge of the organisation: Prof Lamberto Coppini, Via G. A. Perti 20, 40134, Bologna

(2) Person in charge of the organisation: Dr Tarquinio Ladu, Via Londra 7, 09131 Cagliari.

THE SHROUD OF TURIN - REVISITED

by **Dr ANTHONY N. PARUTA, Rhode Island, USA**

The story of the Shroud of Turin is far from over. There is a vast array of coherent scientific data and information from other fields pointing to its authenticity. The dating of the Shroud recently conducted by three laboratories indicated the age of a sample piece of cloth to be 728 years old. No doubt these are reputable and accurate determinations. It is possible (and a well known recurring phenomenon) that experimentally derived values are sometimes anomalous. As an experimental scientist for thirty years I know that an occasional anomalous result is determined which is inexplicable and vastly different from the expected or predicted value. In my own field results can be many multiples of an expected value or a small fraction of a predictable data point. While these radiodating tests could be anomalous their general coherence indicates that the probability is small.

I suggest that the radiational energy which "imprinted" the bodily image on the cloth altered the fibres of the cloth and changed the relative number of carbon isotopes on the linen material. This would render radiodating the age impossible

SHROUD OF TURIN - REVISITED (cont'd)

to determine. The cellulose in the linen is composed of carbon, oxygen and hydrogen. Transmutation of elements, that is, changing one element into another or an isotope into another isotope of the same element is in the order of 10^6 - 10^8 calories and occurs with wavelengths of about 10^{-4} Angstroms. It is this kind of energetic cosmic ray from the sun which causes the formation of carbon-14 from nitrogen in the atmosphere. Thus the cloth age would have been changed by the radiant energy altering the carbon isotope ratios.

The body image, from a purely scientific aspect, necessitates a radiant energy explanation no matter what it shows, (object/event/dead male). The uniqueness of this phenomenon cannot be totally defined by science. With all the studies done on this cloth there is still no definitive mechanism which details how the image was formed. That Jesus was a historical personage who was crucified in the first century in the Roman style cannot be disputed. If one believes that the Jesus of history is the Christ of faith, that will be a religious statement but faith in the resurrection of Jesus does not depend on evidence, scientific or otherwise, from the Shroud of Turin.

There will never be a totally scientific answer to the mysteries science has discovered about the Shroud. If we expect this scientific solution it would be the same as saying that science can completely define God because all the physical and chemical parameters have been determined.

Significant numbers of phenomena that exist in the world are still poorly understood and incompletely characterised. The basic understanding of our world and universe comes from the quantum mechanics and unified field theories (infinitesimally small and infinitely large). There are both visible realities such as earth, water, cars, houses, human beings (= matter) and invisible realities such as gravity, sound, light and electricity (= energy). Our basic understanding of matter comes from quantum mechanics which tells us that we live in a probabilistic (sic) universe. This is due to the understanding of the makeup of atoms where electrons are not points in space but are characterized by existing as electron clouds. Therefore any proofs of scientific merit are really statements of probability. In the case of the Shroud, one piece of seemingly contradictory data is certainly overbalanced by all of the favourable data that has been determined undergirding its authenticity.

It has been truly said that "for those who believe, no explanation is necessary, for those who do not believe, no explanation will suffice."

SHROUD NEWS began in 1980 when Rex Morgan, author of three books on the subject of the Holy Shroud (PERPETUAL MIRACLE -SECRETS OF THE HOLY SHROUD OF TURIN, SHROUD GUIDE and THE HOLY SHROUD AND THE EARLIEST PAINTINGS OF CHRIST) started putting together a few notes about current developments in sindonology (the study of the Shroud of Turin) for a small circle of interested people in his home country of Australia. He didn't expect it to go beyond a few issues.

The bulletin now reaches subscribers all over the world and because of its relatively simple method of production it can be written and produced and the information disseminated more quickly than most news-sheets of a similar kind or the more prestigious journals. It contains information, news, articles and illustrations gathered from sources of Shroud study worldwide through Rex Morgan's extensive personal connections with what has been described as the "Shroud Crowd".

Rex Morgan is a frequent traveller overseas and thus has the opportunity to keep abreast of latest developments in Shroud study and research. He was present at the world media preview of the Shroud itself in August 1978 in Turin, Italy and has met with numerous Shroud researchers in many countries. His quest for information about the Shroud has become, as he describes it, a "passionate hobby". He brought the world-famous Photographic Exhibition created by Brooks Institute, California, to Australia, New Zealand, Hong Kong and Macau and during its tour it attracted more than half a million visitors. The exhibit has now been given to the non-profit making organisation, The South East Asia Research Centre for the Holy Shroud (SEARCH) of which Morgan is President. He is also a member of the Board of Directors of the USA based Association of Scientists and Scholars International for the Shroud of Turin (ASSIST) and was a member of the scientific team which conducted environmental experiments in a Jerusalem tomb in 1986 (The Environmental Study of the Shroud in Jerusalem).

Our list of SHROUD NEWS subscribers continues to increase. We request a subscription in Australia of \$6 for six issues posted. SHROUD NEWS comes out six times per year. The USA subscription for 6 issues is \$US 6 (posted surface mail) or \$US 12 (posted airmail). Postage to other countries varies. ALL back issues are available at \$1 (US or Aust) each plus postage charges.

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All information and opinion in this newsletter is published in good faith. It is edited (and mainly written) by Rex Morgan and published by:

THE RUNCIMAN PRESS, Box 86, PO, MANLY, 2095, NSW, AUSTRALIA