

A CURRENT LOOK AT CARBON DATING

WALTER C. McCrone

In April, 1978, the Scientific Commission of the International Center of Sindonology presented a list of recommended tests to be carried out on the occasion of the Congress in Turin in October. They recommended quite properly that the carbon-dating test be postponed « for the present » because of unanswered questions concerning the status of this analytical procedure. The recommended postponement is quite reasonable as of today; however, there is every reason to believe that all doubts can be resolved in the next several months so that carbon dating of the Shroud sample can then be implemented. Many of the troublesome questions can, even today, be answered and the only remaining questions:

1. sample size, and
2. accuracy of the dating

will very soon also be answered. It would seem appropriate to assume that all questions can be resolved by year's-end and that the Scientific Commission could then recommend that carbon dating proceed.

I would like to cover in this report the present status and expected status by year's end. In addition, I will suggest a protocol for the tests.

Comparison of the Carbon-Dating Procedures

There are two basic methods now available for carbon dating: Dr. Libby's Decay Counting method and mass spectrometer isotope counting methods. The latter is being done by tandem Van De Graaff accelerators and by cyclotrons.

Decay Counting - This is the classical procedure used for the past twenty years. Several laboratories (Brookhaven National Laboratory in Long Island, New York; University of California in San Diego, California; and the National Bureau of Standards in Washington, DC) have specialized in the refinement of this method for small samples. The present limit seems to be about 20 mg of linen (about 1 cm²). Further significant improvement is not likely and a sample 2000 years old would

be dated with an excepted error of about 10% or about ± 200 years.

Spectrometer Methods - There are two such methods based on the type of equipment used: tandem accelerators and cyclotrons. Both have been developed only during the past three years and both understandably have problems. Yet, they are already at least as effective as decay counting and their promise in the earliest future is considerably better than decay counting. The major proponent of the tandem accelerator method is Prof. Harry Gove of the University of Rochester, New York. He has dated several known samples, including two 850 and 4500 years old with sample sizes of 5.6 and 18 mg, respectively, (in terms of linen) and accuracies well below 10%. They expect soon to be able to analyze 2 mg samples with about 1% accuracy. Other very active tandem accelerator laboratories working on carbon dating are located at Simon Fraser University in British Columbia, University of Oxford in England, the atomic energy establishment in Chalk River, Canada and the University of Pennsylvania in the U.S.A.

The cyclotron method is represented by the Lawrence Berkeley Laboratory of the University of California at Berkeley. Hopefully, they may be able to match the performance of the tandem accelerator method when a new sample source now under construction is ready to test. In any case, it seems reasonable that by December 1978 we will have two laboratories (Rochester and Berkeley) able to date a few milligrams of linen with an accuracy of better than 10%. It seems possible now that the accuracy may be better at Berkeley, but that Rochester will be able to date somewhat smaller samples.

In Shroud terms, a 2 mg linen sample corresponds to about 10 mm² of linen (a square about 3.1 mm on edge). One percent accuracy would mean an error of ± 20 years for a 2000 year old sample. The sample size can also be expressed in terms of Shroud thread length (Table 1).

TABLE 1.* - Shroud sample sizes and weights for carbon dating

Weight of linen required (mg)	Dimension of corres. square of Shroud linen		Length of corres. Shroud single thread (cm)	
	Edge (mm)	Area (mm ²)	Warp	Weft
1	2.2	5	6.3	2
2	3.1	10	12.5	4
4	4.4	20	25	8
8	6.3	40	50	16
16	8.9	80	100	32

* Carbon-dating scientists refer to the weight of carbon they require; this is about one-half the weight of the linen required to yield that weight of carbon.

Two samples taken in 1973 from the Shroud and examined by Prof. Raes weigh about 50 and 100 mg, hence are more than adequate for carbon dating. Hopefully, dating can be done in duplicate or triplicate by each of the two mass spectrometer methods.

OTHER CONSIDERATIONS

One must also consider the quality and purity of the sample, methods of preparing the linen for dating and security arrangements for the sample and the final analytical results.

Sample

The samples taken in 1973 were examined very carefully by Prof. Raes and found to be in excellent condition; hardly different from a modern linen sample. Although only carbon-dating impurities interfere with dating and therefore need be considered, there will be carbon-containing contaminants - oils and perspiration from handling by many hands, other stains and perhaps mildew or mold and even particles containing carbon. The amounts of such contamination is very low from my own visual observation, but the preparation method should include a purification step. Fortunately, linen and cotton (also present) are very pure cellulose. A suitable procedure for purification and isolation of only the cellulose portion has been developed in our laboratory. It parallels the industrial process for the manufacture of viscose rayon.

Preparation of the Sample for Dating

Our procedure has several steps:

1. Ultrasonic cleaning of the linen to remove particles of sand, pollen etc.;
2. Dissolution in potassium xanthate and filtration to remove undissolved impurities;
3. Reprecipitation of the cellulose with dilute acid;
4. Filtration and drying of the cellulose;
5. Burning of the cellulose to carbon dioxide;
6. Drying of the carbon dioxide gas and sealing in a glass tube for the cyclotron; or
7. Reduction of the carbon dioxide gas to elemental carbon and preparation of a pressed pellet for the accelerator.

The procedure is straightforward but requires added skills because of the small amounts of material at each step. With such a procedure there is no reason to fear contamination of the Shroud sample. With the above procedure only the original cloth fibers will be dated.

Sample Analysis, Chain of Evidence and Reporting of Results

Fortunately, Prof. Raes made a very careful study of the two cloth samples taken from the Shroud in 1973. Re-examination today by the same microscopical procedures would ensure that the samples are the same identical samples examined by Prof. Raes. We believe both samples should be dated and that both are entirely adequate for the purpose. The samples should be authenticated and processed one at a time by the same laboratory and converted to the final form required by the carbon-dating laboratories. At least duplicate samples should be prepared for each of two dating laboratories, one using a cyclotron and one an accelerator. Several other similar linen samples of varying known dates should also be prepared for submission simultaneously with the Shroud samples. The person authenticating the Shroud samples as the same ones studied by Prof. Raes should maintain the further chain of evidence so that he (and only he) knows for certain the identities of the sample analyzed by the dating laboratories. Each laboratory would receive four blind samples in addition to the Shroud sample and representing the first, sixth and twelfth centuries AD. One laboratory would receive two identical sixth century samples and the other two identical twelfth century samples. The results from the laboratories would be delivered, *still sealed*, to the proper authorities with the key to the identity of the samples. In this way, only the one person opening three sealed envelopes and comparing the data therein would be able to determine the age of the Shroud samples.

Conclusions

Suitable carbon-dating methods will almost certainly be available before January 1979. A procedure avoiding contamination for preparing very small linen samples has been tested. Appropriate samples of linen have already been cut from the Shroud.

We beseech that the two linen samples cut from the Shroud in 1973 and examined by Prof. Raes be released to McCrone Associates, Inc. for preparation for carbon dating. We promise that the state of the art will continue to be monitored and that dating samples will be delivered to the dating laboratories only when successful results are ensured. We pledge that the samples will be handled in a careful forensic manner so that no one can ever doubt the correctness of the results and, finally, we pledge that the dating analyses will be done blind and that only the final authorities to whom the dating analyses and the key to the samples are transmitted shall then know the true Shroud date.