APPENDIX F

RADIOCARBON ANALYSIS

BETA

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Beta Analytic Inc.
4985 SW 74 Court
Miami, Florida 33155 USA
Tel: 305 667 5167
Fax: 305 663 0964
beta@radiocarbon.com
www.radiocarbon.com

MR. DARDEN HOOD
Director

Mr. Ronald Hatfield
Laboratory Manager

Mr. Christopher Patrick
Ms Teresa Zilko-Miller
Associate Managers

May 24,2000

Dr. Larry L. Leach
San Diego State University
Dept. of Anthropology
5500 Campanile Drive
San Diego, CA 92182

Dear Dr. Leach:

Enclosed is the radiocarbon dating result for one sample recently sent to us. It provided plenty of carbon for reliable measurements and the analysis went normally. The report sheet contains the dating result, method used, material type, applied pretreatments and calendar calibration results (where applicable).

This report has been both mailed and sent electronically, along with a graphical representation of a calendar calibration, if appropriate. Calendar calibrations are available as individual Windows metafiles (wmf) upon request. These are useful for incorporating directly into your reports. Calibrations are calculated using the newest (1998) calibration data. References are quoted on the bottom of each calibration page. The upper limit is about 20,000 years for calendar calibration. Multiple probability ranges may appear in some cases, due to short term variations in the atmospheric 14C contents at certain time periods. Examining the calibration graphs will help you understand this phenomenon.

We analyzed this sample on a sole priority basis. No students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analysis. They were analyzed by our full-time professional staff.

Information pages are also enclosed with the mailed copy of this report. They should answer most of any questions you may have, if they do not, please do not hesitate to contact us for specific discussions. Someone is always available to talk to you.

Thank you for prepaying the analysis. A receipt is enclosed.

Sincerely,

BETA ANALYTIC INC.

RADIOCARBON DATING SERVICES

Mr. DARDEN G. HOOD
Director

RONALD E. HATFIELD
Laboratory Manager

CHRISTOPHER PATRICK
TERESA A. ZILKO-MILLER
Associate Manaaers

ANALYTICAL PROCEDURES AND FINAL REPORT

FINAL REPORT

This package includes the final date report, this statement outlining our analytical procedures, a glossary of pretreatment terms, calendar calibration information, billing documents (containing balance/credit information and the number of samples submitted within the yearly discount period), and peripheral items to use with future submittals. The final report includes the individual analysis method, the delivery basis, the material type and the individual pretreatments applied. Please recall any correspondences or communications we may have had regarding sample integrity, size, special considerations or conversions from one analytical technique to another (e.g. radiometric to AMS). The final report has also been sent by fax or e-mail, where available.

PRETREATMENT

Results were obtained on the portion of suitable carbon remaining after any necessary chemical and mechanical pretreatments of the submitted material. Pretreatments were applied, where necessary, to isolate ^{14}C which may best represent the time event of interest. Individual pretreatments are listed on the report next to each result and are defined in the enclosed glossary. When interpreting the results, it is important to consider the pretreatments. Some samples cannot be fully pretreated making their ^{14}C ages more subjective than samples which can be fully pretreated. Some materials receive no pretreatments. Please read the pretreatment glossary.

ANALYSIS

Materials measured by the radiometric technique were analyzed by synthesizing sample carbon to benzene (92% C), measuring for ^{14}C content in a scintillation spectrometer, and then calculating for radiocarbon age. If the Extended Counting Service was used, the ^{14}C content was measured for a greatly extended period of time. AMS results were derived from reduction of sample carbon to graphite (100 %C), along with standards and backgrounds. The graphite was then sent for ^{14}C measurement in an accelerator-mass-spectrometer located at one of six collaborating research facilities, who return the results to us for verification, isotopic fractionation correction, calendar calibration, and reporting.

THE RADIOCARBON AGE AND CALENDAR CALIBRATION

The "Conventional C14 Age (*)" is the result after applying C13/C12 corrections to the measured age and is the most appropriate radiocarbon age (the "*" is discussed at the bottom of the final report). Applicable calendar calibrations are included for organic materials and fresh water carbonates between 0 and 10,000 BP and for marine carbonates between 0 and 8,300 BP. If certain calibrations are not included with this report, the results were either too young, too old, or inappropriate for calibration,

4985 S.W. 74 COURT, MIAMI, FL 33155 U.S.A.
TELEPHONE: 305-667-5167 / FAX: 305-663-0964 / INTERNET: beta@radiocarbon.com
WEB SITE: http://www.radiocarbon.com

BETA ANALYTIC INC.
RADIOCARBON DATING LABORATORY
CALIBRATED C-14 DATING RESULTS

Calibrations of radiocarbon age determinations are applied to convert BP results to calendar years. The short term difference between the two is caused by fluctuations in the heliomagnetic modulation of the galactic cosmic radiation and, recently, large scale burning of fossil fuels and nuclear devices testing. Geomagnetic variations are the probable cause of longer term differences.

The parameters used for the corrections have been obtained through precise analyses of hundreds of samples taken from known-age tree rings of oak, sequoia, and fir up to about 10,000 BP. Calibration using tree-rings to about 12,000 BP is still being researched and provides somewhat less precise correlation. Beyond that, up to about 20,000 BP, correlation using a modeled curve determined from U/Th measurements on corals is used. This data is still highly subjective. Calibrations are provided up to about 19,000 years BP using the most recent calibration data available (Radiocarbon, Vol. 40, No. 3, 1998).

The Pretoria Calibration Procedure (Radiocarbon, Vol 35, No. 1, 1993, pg 317) program has been chosen for these calendar calibrations. It sues splines through the tree-ring data as calibration curves, which eliminates a large part of the statistical scatter of the actual data points. The Spline calibration allows adjustment of the average curve by a quantified closeness-of-fit parameter to the measured data points. A single spline is used for the precise correlation data available back to 9900 BP for terrestrial samples and about 6900 BP for marine samples. Beyond that, splines are taken on the error limits of the correlation curve to account for the lack of precision in the data points.

In describing our calibration curves, the solid bars represent one sigma statistics (68% probability) and the hollow bars represent two sigma statistics (95% probability). Marine carbonate samples that have been corrected for δ 13/12C, have also been corrected for both global and local geographic reservoir effects (as published in Radiocarbon, Volume 35, Number 1, 1993) prior to calibration. Marine carbonates that have not been corrected for δ 13/12C are adjusted by an assumed value of 0 $^{0}/_{00}$ in addition to the reservoir corrections. Reservoir corrections for fresh water carbonates are usually unknown and are generally nor accounted for in those calibrations. In the absence of measured δ 13/12C ratios, a typical value of –5 $^{0}/_{00}$ is assumed for freshwater carbonates.

(Caveat: the correlation curve for organic materials assume that the material dated was living for exactly ten years [e.g. a collection of 10 individual tree rings taken form the outer portion of a tree that was cut down to produce the sample in the feature dated]. For other materials, the maximum and minimum calibrated age ranges given by the computer program are uncertain. The possibility of and "old wood effect" must also be considered, as well as the potential inclusion of younger or older material in matrix samples. Since these factors are indeterminant error in most cases, these calendar calibration results should be used only for illustrative purposes. In the case of carbonates, reservoir correction is theoretical and the local variations are real, highly variable and dependant on provenience. Since imprecision in the correlation data beyond 10,000 years is high, calibrations in this range are likely to change in the future with refinement in the correlation curve, The age ranges and especially the intercept ages generated by the program, must be considered as approximations.)

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -17.2;lab. mult = 1)

Laboratory number: **Beta-141956**

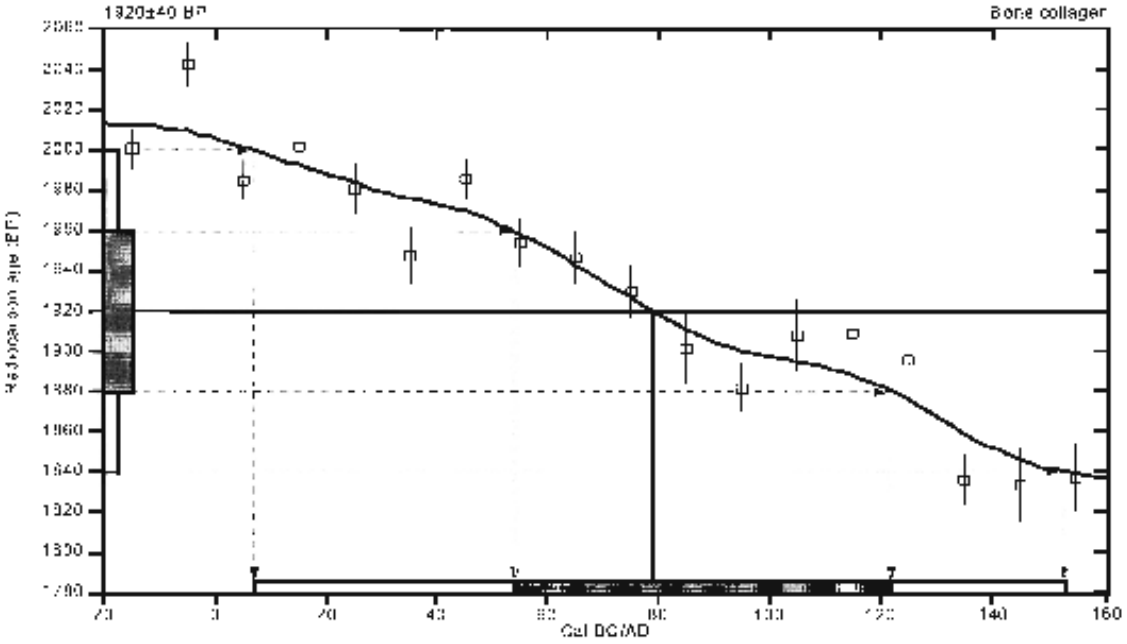
Conventional radiocarbon age: 1920±40 BP

2 Sigma calibrated result: (95% probability) **Cal AD 5 to 155 (Cal BP 1945 to 1795)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 80 (Cal BP 1870)

1 Sigma calibrated result: (68% probability) Cal AD 55 to 120 (Cal BP 1895 to 1830)



References:

Database used
INTCAL98
Calibration Database
Editorial Comment
Stuiver, M., van der Plicht, J., 1998. Radiocarbon 40(3), pxi-xiii
INTCAL98 Radiocarbon Age Calibration
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Mathematics
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Talma, A. S., Vogel, J. C., 1993. Radiocarbon 35(2), p317-322

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4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

BETA

BETA ANALYTIC INC.

DR. M.A. TAMERS and MR. D.G. HOOD

UNIVERSITY BRANCH
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305/667-5167 FAX: 305/663-0964
E-MAIL: beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Dr. Larry L. Leach

San Diego State University

Report Date: 5/24/2000

Material Received: 3/24/2000

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 141956	1800 +/- 40 BP	-17.2 o/oo	1920 +/- 40 BP

SAMPLE : VS766C#2
ANALYSIS : AMS-Standard Delivery
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali
2 SIGMA CALIBRATION : Cal AD 5 to 155 (Cal BP 1945 to 1795)

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By international convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.