APPENDIX I

Global Positioning System Survey
Chocolá Archaeological Site

17 November 2003

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Objectives

The objective of the GPS survey project for 2003 was to define the locations of twelve concrete monuments placed as mapping and survey control points throughout the archaeological site of Chocolá for the Proyecto Arqueológico Chocolá (PACH), a long-term research project in the Guatemalan piedmont which is directed by Dr. Jonathan Kaplan of the University of New Mexico.

Grid data

The maps most commonly used by archaeologists in Guatemala are the 1:50,000 Universal Transverse Mercator Grid series prepared by the Instituto Geográfico Milatar (IGM) Guatemala, with the collaboration of the Defense Mapping Agency Inter American Geodetic Survey. These maps use the 1927 North American Datum (NAD27) as the horizontal datum and Mean Sea Level (MSL) as the vertical datum. These conventions provide a strong argument for reporting data in these same systems. However, there are even stronger reasons for favoring the current WGS84 datum with Height Above Ellipsoid (HAE) as the vertical reference. WGS84 is the native system for GPS receivers and the receivers compute the UTM coordinates and the HAE directly from the WGS84 Cartesian Geocentric Coordinates. GPS receivers and post-processing software translate from WGS84 to NAD27 as well as to other coordinate systems and refer to a database to convert from HAE to MSL or to a Geoid model to convert to Orthometric height. Not all equipment and software support well these legacy systems. The greatest consistency given a variety of equipment and software is obtained by adhering to the WGS84 datum. The grounds of consistency and equipment capacity are compelling for reporting the data in WGS84 datum with HAE as the vertical datum.

Instrumentation and methodology

The instrumentation and methodology for gathering field data in this project is based upon and consistent with the guidelines of a number of publications listed in the bibliography. The controlling documents have been the Federal Geodetic Control Subcommittee, Federal Geographic Data Committee (USA), *Geospatial Positioning Accuracy Standards, Part 2: Standards for Geodetic Networks*, FGDC-STD-007.2-1998, The Intergovernmental Committee on Surveying and Mapping (ICSM), (Australia), *Best Practice Guidelines, Use of the Global Positioning System (GPS) for Surveying Applications*, Version 2.0 - 1 November1997 and The National Geodetic Survey, (USA), *Guidelines for Geodetic Network Surveys Using GPS*. Draft 4, May 15, 2000. These document are current, are detailed in their description of appropriate field methods, and are appropriate to the equipment used in this survey project.

Instrumentation

Three GPS receivers were used to collect the data for the control point survey. Two of the receivers are Trimble 4000SSE Geodetic Surveyors These are dual frequency L1/L2 receivers configured in this survey with geodetic antennas equipped with ground planes. Trimble specifies a horizontal accuracy of 5 mm + 1ppm times the baseline length and a vertical accuracy of 10 mm + 1ppm times the baseline length. The third receiver is a 4000SE GIS Surveyor. For this receiver Trimble specifies an accuracy of +/- 1 cm + 2ppm times the baseline length.[1]

The antennas were mounted on fixed length GPS rover poles stabilized with bipods.

Field Methods

The field survey was conducted on 4 August 2003. The object of the field method was to establish for each of the twelve control points a minimum of two local baselines to other points among the twelve. Each of the twelve control points would also have a baseline to the CORS station in Guatemala City. Time and transport of equipment constraints required a single occupation of each control point and propagation of the network through occupation of proximate control points. Requirements of moving the equipment from point to point combined with local environmental conditions precluded kinematic techniques. A static survey was recorded on each of the twelve control points. Ten of the control points were occupied for one to two hours. Point 50 was occupied for twenty-one minutes and point 19 for thirty-three minutes. The three receivers were moved one at a time so in a pattern to produce a minimum of two local baselines per control point. The pattern of propagation resulted in times of common occupation of local baselines of between 6.75 minutes and 71.42 minutes with an average of 32.52 minutes. The local receivers were set to record at five-second intervals. Thus there were between 81 and 857 common epochs of data recorded with an average of 390. There were a total of twenty baselines recorded among the twelve Chocolá control points.

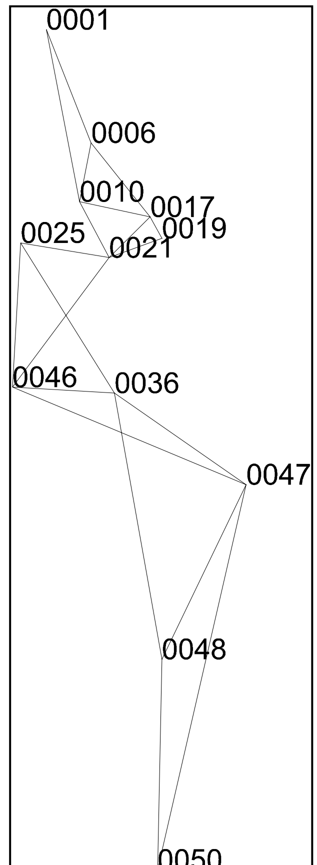

Fig 1 Chocolá control points

Data processing and analysis

All of the GPS data were postprocessed using by the program GeoGenius™ by Spectra Precision Terrasat GmbH, Hoehenkirchen, Germany. This program is designed to integrate terrestrial and satellite data and produces a number of reports permitting evaluation of the quality of the data and providing for the transfer of the data to the GIS system.[2]

The Guatemala City CORS records at thirty-second intervals. Data downloaded from the CORS site produced eleven usable baselines between Chocolá control points and the Guatemala City CORS with between 42 and 246 common epochs of data with an average of 156 common epochs.

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[1] The GPS receivers were provided by Trimble Navigation Limited, Sunnyyvale, CA.

[2] The GeoGenius™ program was provided by Spectra Precision.

The GeoGenius™ GPS postprocessing software computes the carrier phase solution to the baseline vector. The carrier signal from the satellite to the receiver consists of an integer number of complete cycles plus a fraction of a cycle. The GPS receiver can measure the time elapsed since the last phase shift in the carrier signal to about 1/100 of a cycle, that is near 2 mm for the 19 cm Ll carrier and the 23 cm L2 carrier. The unknown number of complete cycles between the satellite and the receiver is known as the integer ambiguity. Carrier phase processing software attempts to resolve this integer ambiguity.

The principal sources of possible error in GPS positioning are ionospheric delay of the GPS signal and errors in the satellite and the receiver clocks. The amount of delay in the ionosphere is a function of the frequency of the signal. Using dual frequency receivers in conjunction with a model of the ionosphere effectively eliminates the error due to the ionosphere. Clock errors are eliminated by phase differencing techniques. Single differences are the differences between the carrier-phase observations of two receivers of the same satellite at the same epoch. Since the differences are of the same satellite, the satellite clock error is canceled. Double differences are the differences of two single differences of the same epoch that refer to two different satellites. Since double differences are from the same receiver, the receiver clock error is canceled. The triple difference is the difference between the double differences at two receivers, that is, the carrier-phase observations between two receivers, two satellites and two epochs. Because the integer ambiguity is a constant in time, the triple difference does not depend on this variable. The integer ambiguity only depends on the initial observation. The receiver keeps track of the number of whole cycles that it has received since first acquisition of the signal. The triple difference is used to detect and recover from cycle slips in the count. It also provides a first solution to the receiver position.

With confidence in the cycle count, the program computes a double difference float solution. It is called a float solution because the integer ambiguities are permitted to float, that is the algorithm does not force them to be integers. The double difference solution allows processing correlated double difference carrier phase data. With dual-frequency data, additional baseline solutions will be provided for the various combinations of L1 and L2 known as Lw, Lc and Ln.

A search for a more accurate solution is conducted within a window that is defined as twenty times the sigma value of the double difference float solution. The algorithm constrains the ambiguity to integers and searches the volume for the solution with the smallest sum of squares residual error. Statistical testing is used to verify the correctness of the ambiguity resolution. First a Fisher test is performed with the ratios of the variances of the second to the best fitting solution with a reliability requirement of 99.99%. Then a Chi-square test is performed on the a posteriori variance of the residuals with a default of a 95% minimum probability. If this process is successful the solution is said to be a fixed solution; if it is not successful the solution is said to be a float solution.

Sixteen of the twenty local baselines at Chocolá and four of the ten baselines Guatemala City CORS are fixed solutions. Because of the degree of redundancy in the network, all of the control points are points on at least one fixed baseline. Two have one fixed local baseline and one of those has a fixed solution to Guatemala City CORS. Four of the control points have two local fixed baselines; two have three fixed baselines and four have four fixed baselines. This provides for a high degree of confidence in the accuracy and the precision of the network.

ArchMapBZ control point network accuracy and precision

When used in the context of GPS mapping the *accuracy* refers to the confidence with which the absolute location of the receiver is known and the term *precision* refers to the confidence with which the base line between the base station and the rover is known.

Network accuracy

The network accuracy of the Chocolá control point network was determined by a least squares adjustment of baselines among the control points and the Guatemala City. Ten of the control points within the survey fall within the Federal Geographic Data Committee[3] 5-centimeter horizontal classification. The degree of error in this adjustment is displayed in the table below. The postprocessing program, *GeoGenius*, reports the adjustment error as error ellipses. The FGDC classification is based on a 95% Confidence Error Circle. This figure is computed as the mean between the two values of the error ellipse.[4] It is this figure that is the basis for the assignment of the accuracy of a station to an FGDC horizontal classification. The vertical classification is based upon the height error reported

Network accuracy, adjustment biased by CORS

Control Point	2 sigma error, mm.			95% circle	FGDC H Class	FGDC V Class
	North	East	Height			
1	66.7	84.5	197.6	75.6	1-Decimeter	2-Decimeter
6	49.9	62.7	165.4	56.3	1-Decimeter	2-Decimeter
10	38.0	46.9	124.9	42.5	5-Centimeter	2-Decimeter
17	37.5	52.6	120.1	45.1	5-Centimeter	2-Decimeter
19	35.7	37.8	96.1	36.8	5-Centimeter	1-Decimeter
21	24.9	34.3	86.3	29.6	5-Centimeter	1-Decimeter
25	30.3	41.9	116.2	36.1	5-Centimeter	2-Decimeter

---

[3] Federal Geographic Data Committee, Federal Geodetic Control Subcommittee, *Geospatial Positioning Accuracy Standards, Part 2: Standards for Geodetic Networks*, Table 2-1, Accuracy Standards, p. 2-3

The Federal Geographic Data Committee is established by Office of Management and Budget Circular A-16, the Federal Geographic Data Committee (FGDC) promotes the coordinated development, use, sharing, and dissemination of geographic data. The FGDC is composed of representatives from the Departments of Agriculture, Commerce, Defense, Energy, Housing and Urban Development, the Interior, State, and Transportation; the Environmental Protection Agency; the Federal Emergency Management Agency; the Library of Congress; the National Aeronautics and Space Administration; the National Archives and Records Administration; and the Tennessee Valley Authority. Additional Federal agencies participate on FGDC subcommittees and working groups. The Department of the Interior chairs the committee. FGDC subcommittees work on issues related to data categories coordinated under the circular. Subcommittees establish and implement standards for data content, quality, and transfer; encourage the exchange of information and the transfer of data; and organize the collection of geographic data to reduce duplication of effort. Working groups are established for issues that transcend data categories.

[4] Federal Geographic Data Committee, Federal Geodetic Control Subcommittee, *Geospatial Positioning Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy.* p. 3-6

36	28.6	39.2	100.6	33.9	5-Centimeter	2-Decimeter
46	27.8	38.2	96.3	33.0	5-Centimeter	1-Decimeter
47	29.6	40.0	103.5	34.8	5-Centimeter	2-Decimeter
48	34.9	43.5	113.7	39.2	5-Centimeter	2-Decimeter
50	42.4	49.0	124.4	45.7	5-Centimeter	2-Decimeter
GUAT	68.0	111.3	174.0	89.7	1-Decimeter	2-Decimeter

These data are within the Network Accuracy Standards minimally acceptable levels of differential relative positional accuracy required of a United States Government cadastral survey.[5]

ArchMapBZ control point coordinate values

Control Point WGS84 coordinates

Point Number	X[m]	Y[m]	Z[m]
1	-154108.070	-6171630.157	1600741.029
6	-153946.352	-6171710.835	1600324.559
10	-153991.873	-6171749.464	1600108.722
17	-153730.608	-6171762.635	1600049.989
19	-153688.485	-6171782.943	1599972.674
21	-153885.308	-6171794.963	1599904.016
25	-154212.436	-6171770.002	1599958.785
36	-153870.771	-6171883.238	1599406.108
46	-154248.757	-6171870.408	1599430.753
47	-153386.706	-6171967.489	1599069.374
48	-153706.620	-6172074.446	1598430.012
50	-153732.105	-6172232.012	1597661.624
GUAT	-56062.996	-6174980.368	1596665.507

Control Point UTM coordinates, latitude and longitude, WGS84, UTM 15N

Point Number	North[m]	East[m]	HAE	Orthom. Height [m]	Latitude	Longitude
1	1617973.581	669048.916	923.002	923.542	N 14°37'47.53206"	W 91°25'49.44451"
6	1617552.483	669215.485	891.961	892.511	N 14°37'33.79321"	W 91°25'43.97581"

[5] United States Department of Agriculture, Forest Service, United States Department of the Interior, Bureau of Land Management, *Standards and Guidelines For Cadastral Surveys Using Global Positioning System Methods*, March 21, 2001, p. 6.

10	1617333.339	669172.466	875.928	876.491	N 14°37'26.67259"	W 91°25'45.46404"
17	1617276.653	669434.329	867.540	868.098	N 14°37'24.76914"	W 91°25'36.72681"
19	1617197.294	669477.489	866.650	867.209	N 14°37'22.17728"	W 91°25'35.30301"
21	1617125.241	669281.556	865.688	866.255	N 14°37'19.87709"	W 91°25'41.86687"
25	1617180.196	668953.578	863.268	863.841	N 14°37'21.73902"	W 91°25'52.81370"
36	1616621.490	669301.775	825.053	825.636	N 14°37'03.48189"	W 91°25'41.30784"
46	1616643.574	668923.492	827.989	828.581	N 14°37'04.28557"	W 91°25'53.94298"
47	1616280.877	669790.076	809.925	810.506	N 14°36'52.28914"	W 91°25'25.07043"
48	1615631.138	669477.474	759.801	760.412	N 14°36'31.21902"	W 91°25'35.66624"
50	1614847.696	669461.348	719.089	719.725	N 14°36'05.73166"	W 91°25'36.38635"
GUAT	1614480.619	767173.488	1521.572	1519.880	N 14°35'25.44851"	W 90°31'12.63839"

Appendix 1: GPS receivers

Geodetic surveyors

GPS Receiver	Trimble	**GPS Antenna**	Trimble
Model	4000SSE Geodetic Surveyor	**Model**	Geodetic with ground plane
Part No.	18292-01	**Part No.**	14177-00
Serial No.	3244A01763	**Serial No.**	
Firmware	7.29		

GPS Receiver	Trimble	**GPS Antenna**	Trimble
Model	4000SSE Geodetic Surveyor	**Model**	Geodetic with ground plane
Part No.	18292-01	**Part No.**	14177-00
Serial No.	3610A14748	**Serial No.**	3017A00164
Firmware	7.29		

GIS Surveyor

GPS Receiver	Trimble	**GPS Antenna**	Trimble
Model	4000SE GIS Surveyor	**Model**	Compact L1
Part No.	18292-01	**Part No.**	
Serial No.	3301A02301	**Serial No.**	
Firmware	7.23		

Appendix 2: NGS data sheet for Gueatemala City CORS

```
                     ***ITRF 00***
                GUATEMALA CITY (GUAT),  UNIDENTIFIED DEPARTMENT OF
GUATEMALA

 Retrieved from NGS DataBase on 10/29/02 at 15:50:01.

_______________________________________________________________________
_____
|
|
|         Antenna Reference Point (ARP): GUATEMALA CITY CORS ARP
|
|         -----------------------------------------------------
|
|                             PID = AI7441
|
|
|
|
|
| ITRF00 POSITION (EPOCH 1997.0)
|
| Computed in Aug. 2001 using every third day of data through 2000.
|
|     X =    -56063.630 m     latitude    =  14 35 25.45425 N
|
|     Y =  -6174978.670 m     longitude   = 090 31 12.66007 W
|
|     Z =   1596665.249 m     ellipsoid height = 1519.869   m
|
|
|
| ITRF00 VELOCITY
|
| Predicted with HTDP_2.5 in Aug. 2001.
|
|     VX =   0.0036 m/yr      northward =  -0.0012 m/yr
|
|     VY =  -0.0003 m/yr      eastward  =   0.0036 m/yr
|
|     VZ =  -0.0012 m/yr      upward    =   0.0000 m/yr
|
|
|
|
|
| NAD_83 POSITION (EPOCH 2002.0)
|
| Transformed from ITRF00 (epoch 1997.0) position in Mar. 2002.
|
|     X =    -56062.996 m     latitude    =  14 35 25.44852 N
|
|     Y =  -6174980.368 m     longitude   = 090 31 12.63838 W
|
```

```
|     Z =   1596665.507 m     ellipsoid height = 1521.572   m
|
|
|
| NAD_83 VELOCITY
|
| Transformed from ITRF00 velocity in Mar. 2002.
|
|     VX =   0.0117 m/yr      northward =   0.0013 m/yr
|
|     VY =   0.0006 m/yr      eastward  =   0.0117 m/yr
|
|     VZ =   0.0012 m/yr      upward    =  -0.0004 m/yr
|
|______________________________________________________________________
______|
|
|
| L1 Phase Center of the current GPS antenna: GUATEMALA CITY CORS L1 PC
C    |
| ----------------------------------------------------------------------
--    |
| The D/M element, chokerings, -radome antenna
|
| (Antenna Code = TRM29659.00) was installed on 07/28/00.
|
|        The L2 phase center is 0.018 m above the L1 phase center.
|
|                              PID = AI7442
|
|
|
|
|
| ITRF00 POSITION (EPOCH 1997.0)
|
| Computed in Aug. 2001 using every third day of data through 2000.
|
|     X =    -56063.630 m     latitude    =  14 35 25.45429 N
|
|     Y =  -6174978.776 m     longitude   = 090 31 12.66005 W
|
|     Z =   1596665.278 m     ellipsoid height = 1519.979   m
|
|
|
| The ITRF00 VELOCITY of the L1 PC is the same as that for the ARP.
|
|
|
|
|
| NAD_83 POSITION (EPOCH 2002.0)
|
| Transformed from ITRF00 (epoch 1997.0) position in Mar. 2002.
|
```

```
|     X =    -56062.996 m     latitude    =  14 35 25.44856 N
|
|     Y =  -6174980.474 m     longitude   = 090 31 12.63836 W
|
|     Z =   1596665.536 m     ellipsoid height = 1521.682   m
|
|
|
| The NAD_83 VELOCITY of the L1 PC is the same as that for the ARP.
|
|______________________________________________________________________
______|
```

```
 * Latitude, longitude and ellipsoid height are computed from their
   corresponding cartesian coordinates using dimensions for the
   GRS 80 ellipsoid: semi-major axis = 6,378,137.0 meters
                          flattening = 1/298.257222101...\other
   relevant points at the site and on GPS equipment, consult the
   link ftp://www.ngs.noaa.gov/cors/.html/guat.log.txt


 * The NAD_83 position & velocity were revised in Mar. 2002.
```

Bibliography

United States Department of Agriculture, Forest Service, United States Department of the Interior, Bureau of Land Management, *Standards and Guidelines For Cadastral Surveys Using Global Positioning System Methods*, March 21, 2001.

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US Army Corps of Engineers, Engineering And Design, *NAVSTAR Global Positioning System Surveying Engineer Manual*, EM 1110-1-1003, 1 August 1996

National Geodetic Survey, Guidelines for Geodetic Network Surveys Using GPS, Including Federal & Cooperative Base Network Surveys, User Densification Network Surveys, Gps Orthometric Height Surveys, DRAFT 4, May 15, 2000, National Geodetic Survey, N/NGS2, NOAA, 1315 East-West Highway, Silver Spring, Maryland 20910-3282, email: davez@ngs.noaa.gov or steve@ngs.noaa.gov

Birchall, C. J. and R. N. Jenkin, *The Soils of the Belize Valley, Belize*, Vol. 1 and 2, Land Resources Development Centre, Supplementary Report 15, 1979.

Dr. Jonathan Kaplan

Report Date: 12/20/2004

Material Received: 11/17/2004

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 198188	2240 +/- 40 BP	-25.6 o/oo	2230 +/- 40 BP

SAMPLE : 4-72-4 211
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 390 to 190 (Cal BP 2340 to 2140)

Beta - 198189	2220 +/- 60 BP	-26.5 o/oo	2200 +/- 60 BP

SAMPLE : 4-72-5 258
ANALYSIS : Radiometric-Standard delivery (with extended counting)
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 390 to 80 (Cal BP 2340 to 2030)

Beta - 198190	2250 +/- 40 BP	-28.2 o/oo	2200 +/- 40 BP

SAMPLE : 4-72-6 260
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 380 to 160 (Cal BP 2330 to 2120)

Beta - 198191	2240 +/- 40 BP	-28.5 o/oo	2180 +/- 40 BP

SAMPLE : 4-72-7 262
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 370 to 110 (Cal BP 2320 to 2060)

Beta - 198192	2250 +/- 110 BP	-27.5 o/oo	2210 +/- 110 BP

SAMPLE : 4-72-8 264
ANALYSIS : Radiometric-Standard delivery (with extended counting)
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 500 to 460 (Cal BP 2450 to 2410) AND Cal BC 430 to Cal AD 20 (Cal BP 2380 to 1930)

Dr. Jonathan Kaplan | Report Date: 12/20/2004

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 198194	2220 +/- 40 BP	-26.7 o/oo	2190 +/- 40 BP

SAMPLE : 4-91-6 231
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 380 to 160 (Cal BP 2330 to 2100)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 198196	2120 +/- 40 BP	-24.9 o/oo	2120 +/- 40 BP

SAMPLE : 4-91-8 235
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 350 to 310 (Cal BP 2300 to 2260) AND Cal BC 210 to 40 (Cal BP 2160 to 1990)

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.6:lab. mult=1)

Laboratory number: **Beta-198188**

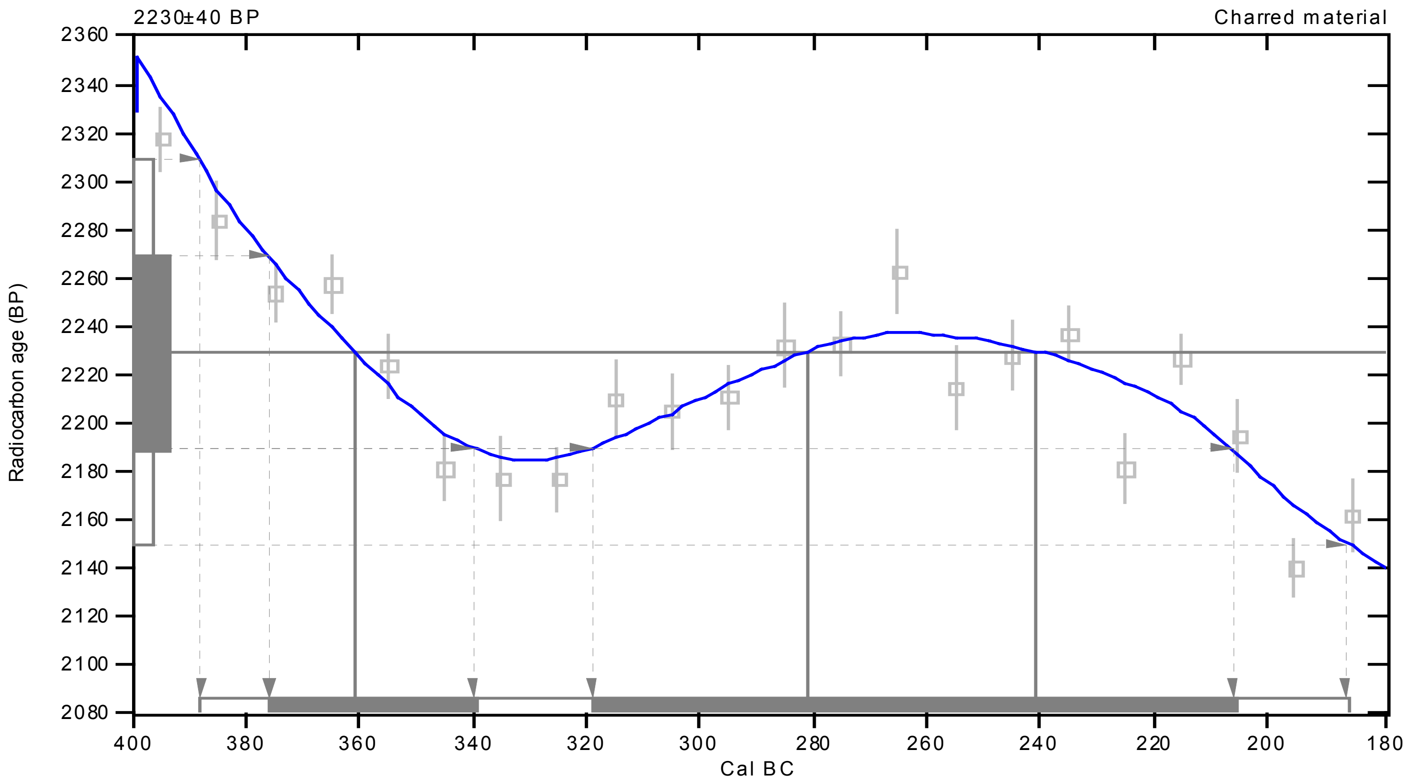
Conventional radiocarbon age: **2230±40 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 390 to 190 (Cal BP 2340 to 2140)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal BC 360 (Cal BP 2310) and
Cal BC 280 (Cal BP 2230) and
Cal BC 240 (Cal BP 2190)

1 Sigma calibrated results: (68% probability) Cal BC 380 to 340 (Cal BP 2330 to 2290) and
Cal BC 320 to 210 (Cal BP 2270 to 2160)



References:

Database used

INTCAL98

Calibration Database

Editorial Comment

Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii

INTCAL98 Radiocarbon Age Calibration

Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

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

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.5:lab. mult=1)

Laboratory number: **Beta-198189**

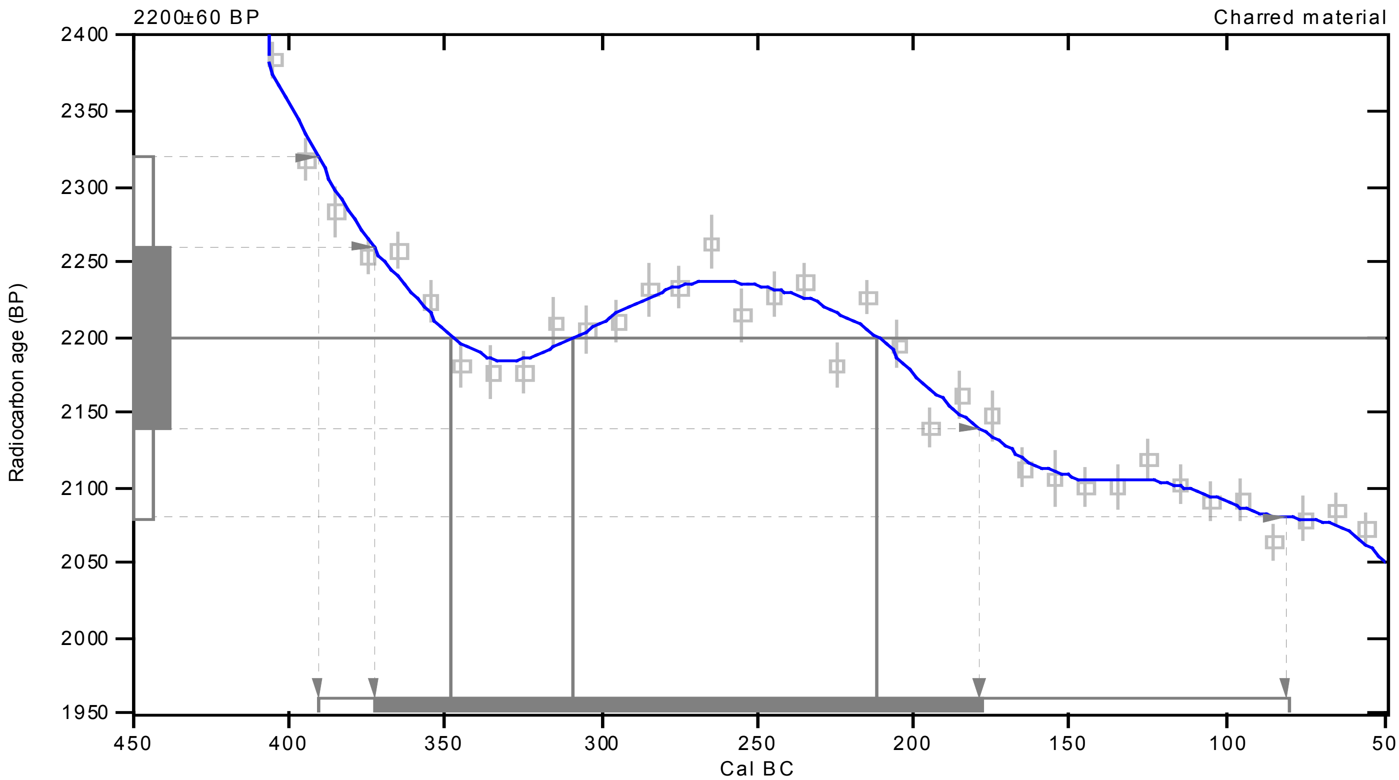
Conventional radiocarbon age: **2200±60 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 390 to 80 (Cal BP 2340 to 2030)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal BC 350 (Cal BP 2300) and
Cal BC 310 (Cal BP 2260) and
Cal BC 210 (Cal BP 2160)

1 Sigma calibrated result: (68% probability) Cal BC 370 to 180 (Cal BP 2320 to 2130)



References:

Database used
INTCAL98
Calibration Database
Editorial Comment
Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii
INTCAL98 Radiocarbon Age Calibration
Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

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

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-28.2:lab. mult=1)

Laboratory number: **Beta-198190**

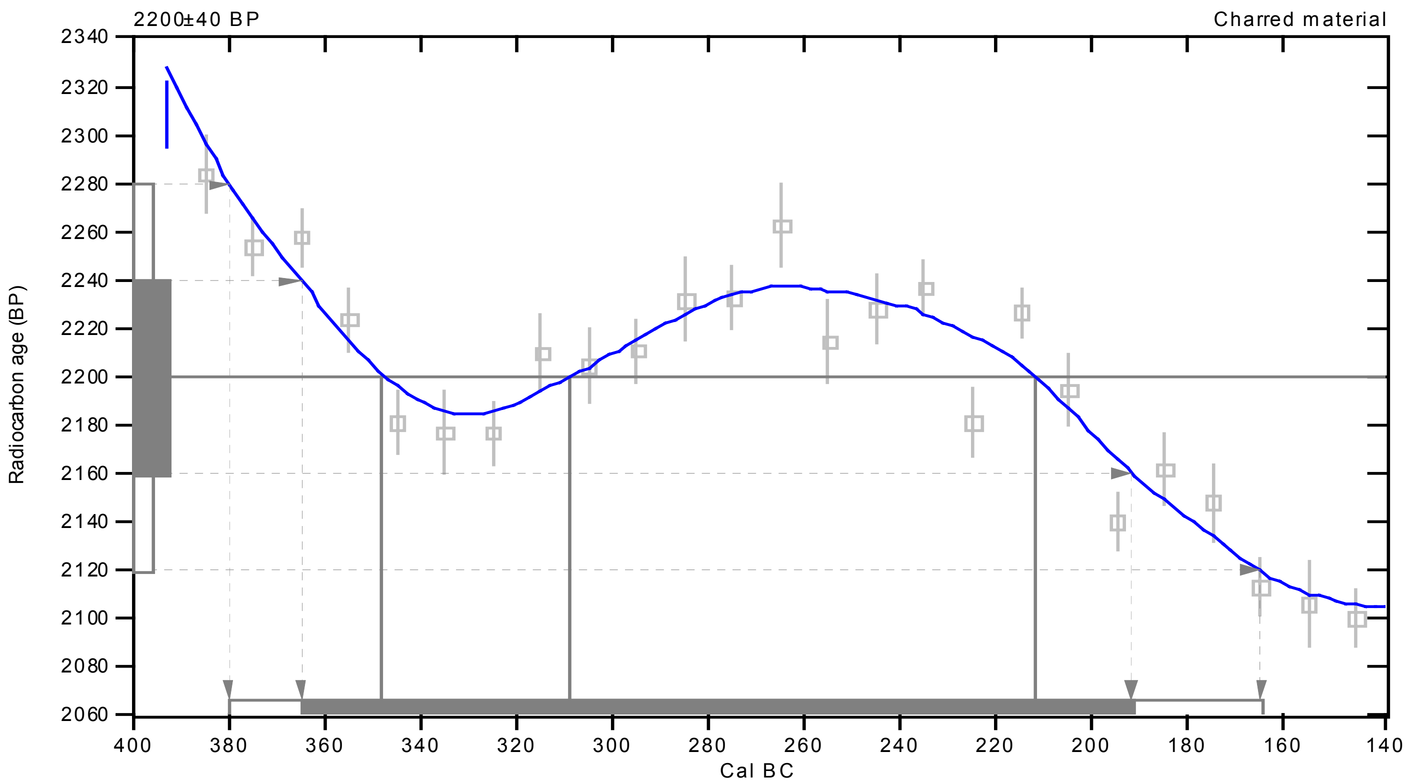
Conventional radiocarbon age: **2200±40 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 380 to 160 (Cal BP 2330 to 2120)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal BC 350 (Cal BP 2300) and
Cal BC 310 (Cal BP 2260) and
Cal BC 210 (Cal BP 2160)

1 Sigma calibrated result: (68% probability) Cal BC 360 to 190 (Cal BP 2320 to 2140)



References:

Database used
INTCAL98
Calibration Database
Editorial Comment
Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii
INTCAL98 Radiocarbon Age Calibration
Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-28.5:lab. mult=1)

Laboratory number: **Beta-198191**

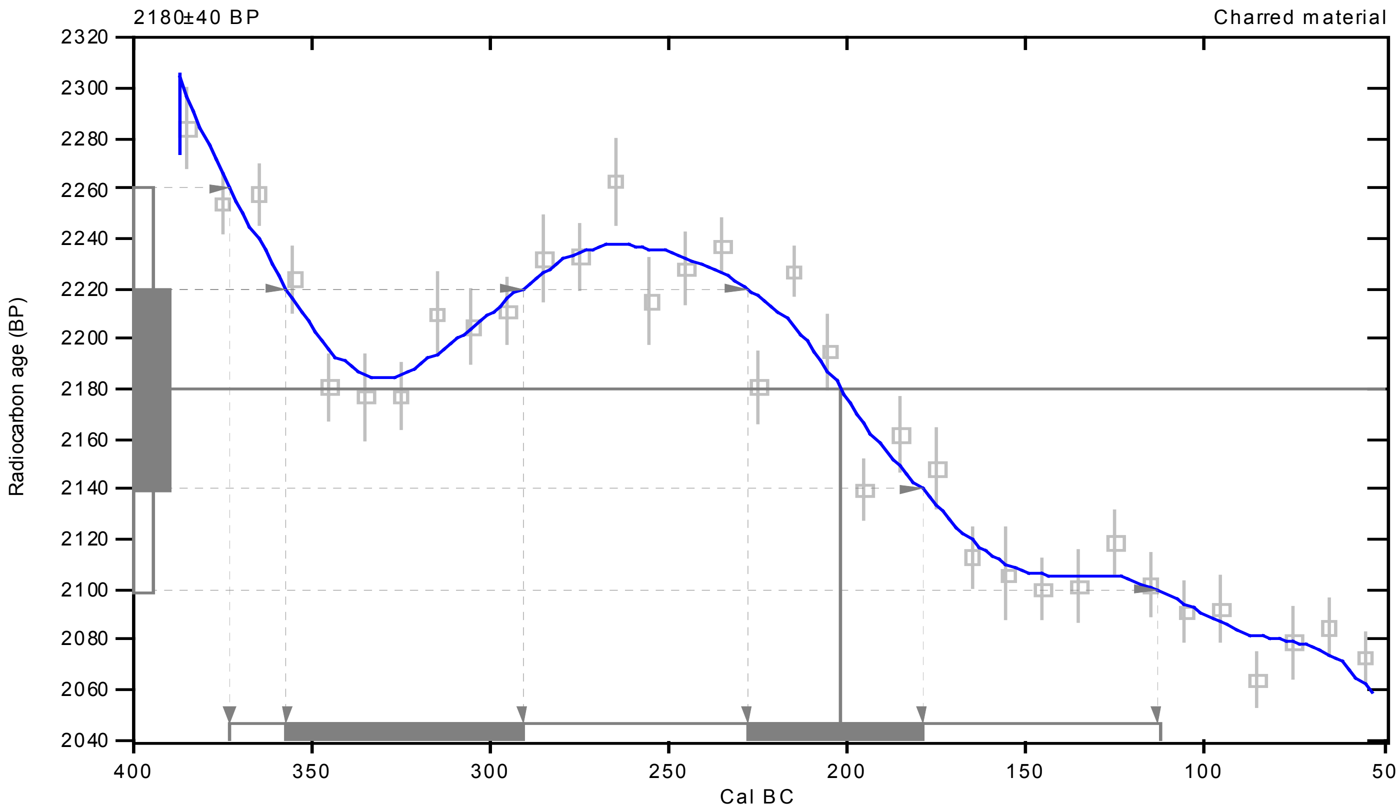
Conventional radiocarbon age: **2180±40 BP**

2 Sigma calibrated result: **Cal BC 370 to 110 (Cal BP 2320 to 2060)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 200 (Cal BP 2150)

1 Sigma calibrated results: Cal BC 360 to 290 (Cal BP 2310 to 2240) and
(68% probability) Cal BC 230 to 180 (Cal BP 2180 to 2130)



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-27.5:lab. mult=1)

Laboratory number: **Beta-198192**

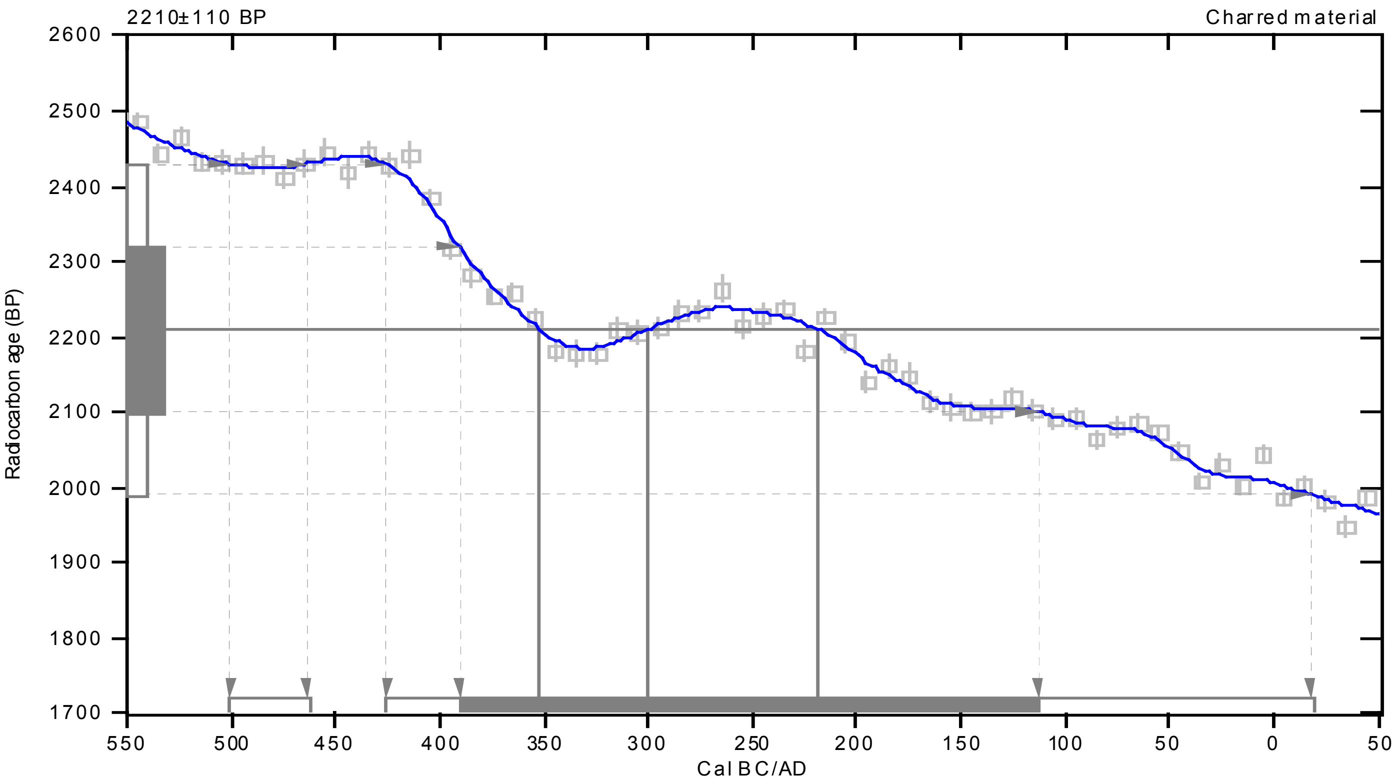
Conventional radiocarbon age: **2210±110 BP**

2 Sigma calibrated results: **Cal BC 500 to 460 (Cal BP 2450 to 2410) and**
(95% probability) **Cal BC 430 to Cal AD 20 (Cal BP 2380 to 1930)**

Intercept data

Intercepts of radiocarbon age
with calibration curve: Cal BC 350 (Cal BP 2300) and
Cal BC 300 (Cal BP 2250) and
Cal BC 220 (Cal BP 2170)

1 Sigma calibrated result: Cal BC 390 to 110 (Cal BP 2340 to 2060)
(68% probability)



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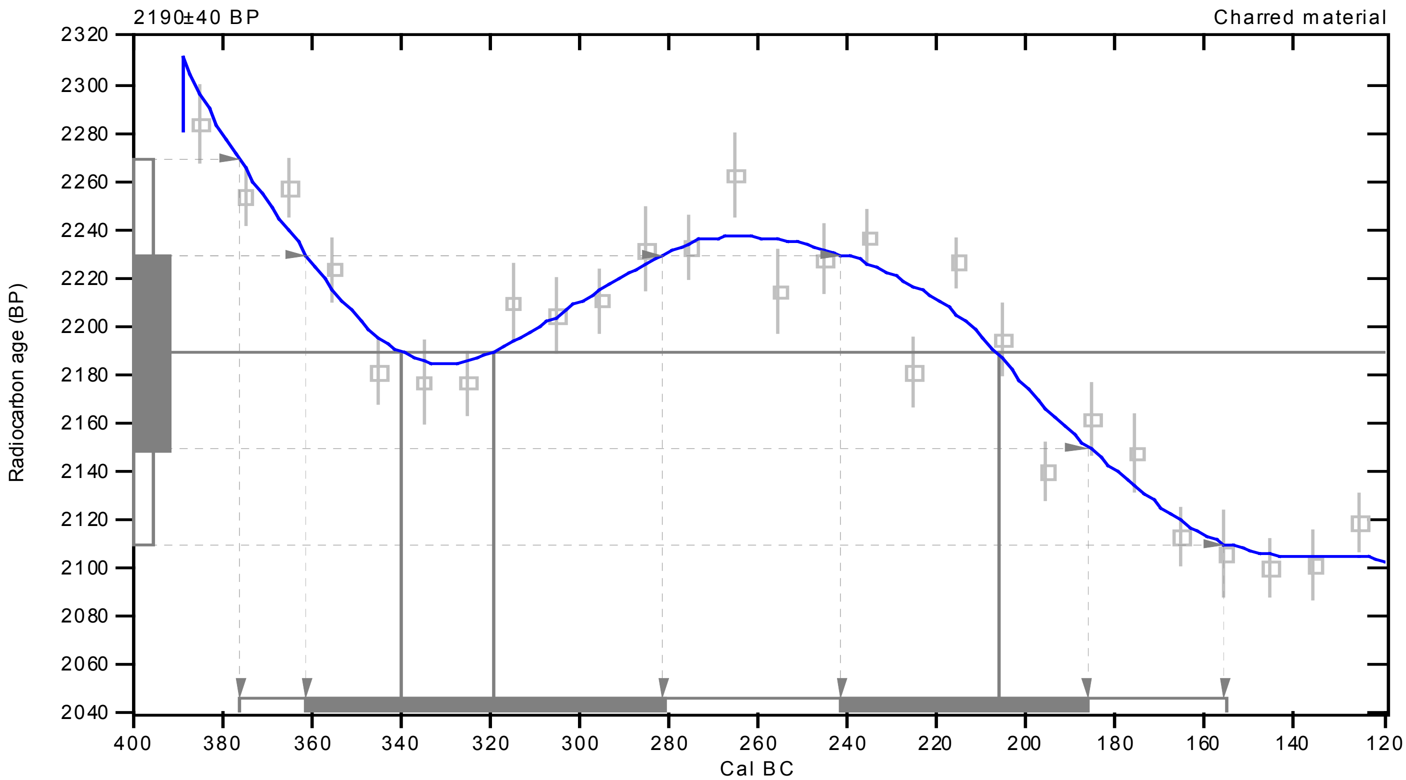
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.7:lab. mult=1)

Laboratory number:	**Beta-198194**
Conventional radiocarbon age:	**2190±40 BP**
2 Sigma calibrated result: (95% probability)	**Cal BC 380 to 160 (Cal BP 2330 to 2100)**

Intercept data

Intercepts of radiocarbon age with calibration curve:	Cal BC 340 (Cal BP 2290) and Cal BC 320 (Cal BP 2270) and Cal BC 210 (Cal BP 2160)
1 Sigma calibrated results: (68% probability)	Cal BC 360 to 280 (Cal BP 2310 to 2230) and Cal BC 240 to 190 (Cal BP 2190 to 2140)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.9:lab. mult=1)

Laboratory number: **Beta-198196**

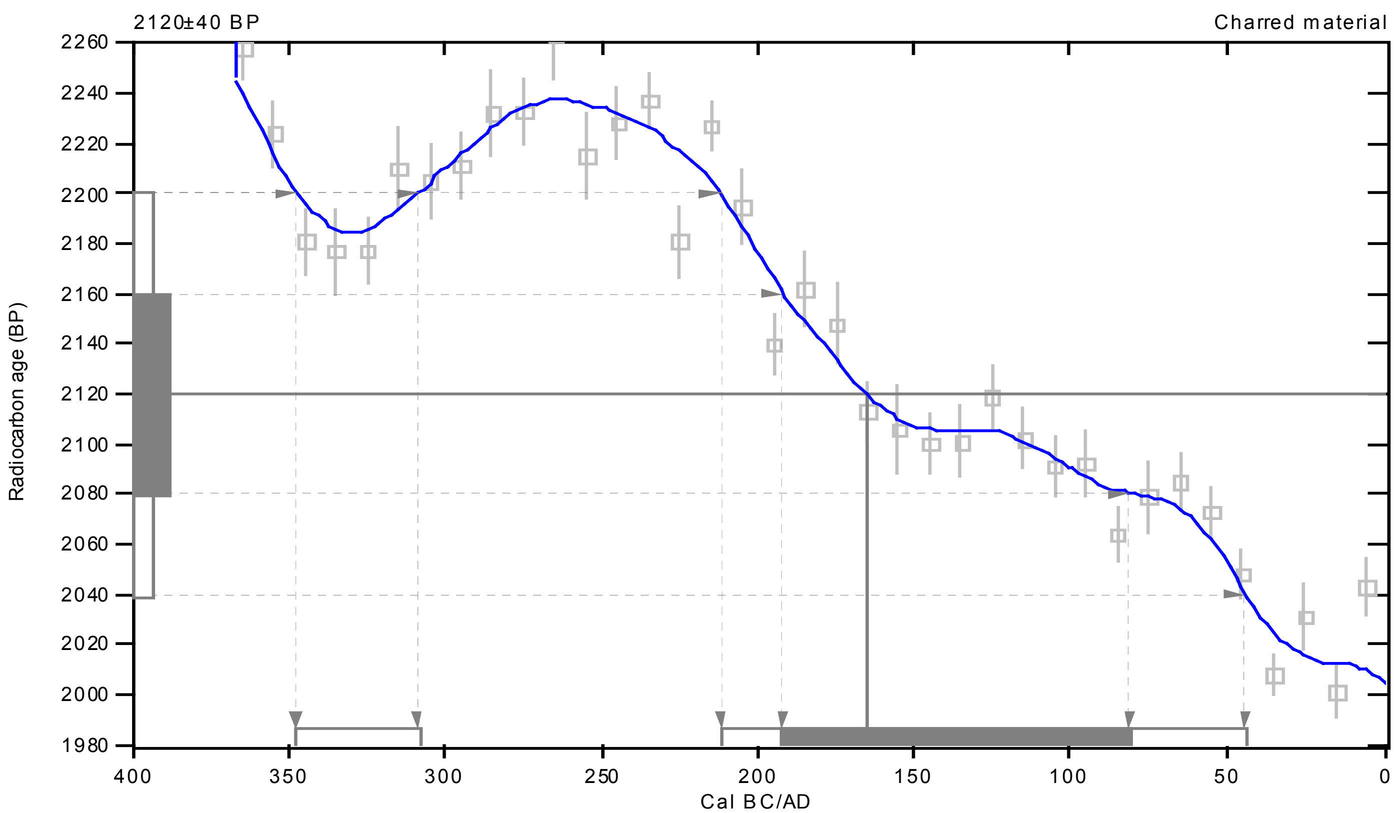
Conventional radiocarbon age: **2120±40 BP**

2 Sigma calibrated results: (95% probability) **Cal BC 350 to 310 (Cal BP 2300 to 2260) and Cal BC 210 to 40 (Cal BP 2160 to 1990)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 160 (Cal BP 2120)

1 Sigma calibrated result: (68% probability) Cal BC 190 to 80 (Cal BP 2140 to 2030)



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Field Methodology, Mound 5, Chocolá, 2004 Season

La operación sobre el Montículo 15 fue abreviada en la nomenclatura de PACH como Operación 14. Features on Mound 5 which had been discovered during the 2003 season and which were suggestive of permanent architecture were deemed sufficiently interesting to explore in a fuller manner in 2004. The decision was taken to undertake intensive excavations employing a Cartesian grid system of 2 x 2 m grid units. In similar manner to that described above for excavations on Mound 15, JK instructed David Monsees to gradiometrically prospect the mound to help decide where to begin excavations, in this case out and around from the stone alignment discovered during the last days of the 2003 season, and which lay approximately one m below ground surface toward the east off the gentle slope of Mound 5. Using a total station a permanent benchmark (BM 50) anchored the shooting in of datums and subdatums to create the grid. The original 20 x 20 m grid, established with stakes and triangulation, reading from the total-station located datums and subdatums, later was expanded such that several 20 x 20 m grids around the original were established during the course of the excavations as necessary dependent on the findings below ground of what turned out to be a massive stone-walled platform structure extending from the furthermost east point – the east wall of which part belonged to the 2003 feature – 45 m west to the west wall and, to the north, from the north wall 40 m south to what we believe constitutes the south wall, based on the finding of an apparent southeast corner. The entire structure – if our estimated dimensions and orientations are correct – constitutes nearly the entirety of the topographically elevated Mound 5, with some allowance for collapse and other taphonomic processes such as crop turbation, other human interventions and disturbances, chiefly agricultural, and millennia of weather and longer-term geophysical cycles and events.

Once gradiometric prospection had been completed and hot-spots noted, excavation was guided by prompt discoveries of major cobble wall architecture, with the north wall emerging first, followed by the east wall. Continuing to adhere to a Cartesian grid unit procedure – rather than, as is sometimes practiced in the lowlands, by excavating architecture without a systematic grid recovery of information – excavators were instructed to pursue by grid units west along the north wall and south along the east wall. In this manner, precise provenience information was obtained, controlled by constant tie-in to datums which had precisely known locations through measurements with the total station and by relation to BM 50.

In addition to seeking horizontally to delineate the outline of the platform, at least once the probable floor contemporary with the first course of the eight-course north wall was reached, vertical or diachronic investigations were undertaken, the location selected being the center of the mound. However, these latter investigations also ceased with discovery of a major burned clay feature; further investigations of this feature are contemplated for the future. These central pits, like all the other units, were tied in to the absolute locations known from BM 50.