

APPENDIX D RADIOCARBON LABORATORY RESULTS

Table D-1. Summary of samples sent to Beta Analytic and Washington State University for laboratory testing.

| Field Sample ID | Sample Type | Laboratory | Analysis | Beta ID | Natural Exposure (WP) / Test Pit (TP) | WP/TP # | Unit |
|--------------------|-----------------------|-----------------------------|-----------------|---------|---------------------------------------|---------|----------|
| HC-WP-1-1 | Charcoal | Beta Analytic | AMS | 382396 | WP | 1 | 1 |
| HC-WP-2-Bridge | Wood | Beta Analytic | AMS | 382397 | WP | 2 | Bridge-2 |
| HC-WP-4-Bridge | Wood and organic soil | Beta Analytic | AMS | 382398 | WP | 4 | Bridge-1 |
| HC-WP-4-Org4 (TPX) | Organic soil | Beta Analytic | AMS | 382399 | WP | 4 | Org4 |
| HC-WP-AP1 | Charcoal | Beta Analytic | AMS | 382400 | WP | AP1 | 1 |
| HC-TP-1 | Charcoal | Beta Analytic | AMS | 382402 | TP | 1 | 1 |
| HC-TP-5-1 | Charcoal | Beta Analytic | AMS | 382403 | TP | 5 | 1 |
| HC-TP-7-1 | Charcoal | Beta Analytic | AMS | 382406 | TP | 7 | 1 |
| HC-TP-7-2 | Charcoal | Beta Analytic | AMS | 382407 | TP | 7 | 2 |
| HC-TP-7-3 | Wood | Beta Analytic | AMS | 382408 | TP | 7 | 3 |
| HC-TP-7-4 | Bone | Beta Analytic | AMS | 382780 | TP | 7 | 4 |
| HC-TP-8-1 | Bone | Beta Analytic | AMS | 382781 | TP | 8 | 1 |
| HC-TP-8-3 | Bone | Beta Analytic | AMS | 382782 | TP | 8 | 3 |
| HC-TP-8-4 | Bone | Beta Analytic | AMS | 382783 | TP | 8 | 4 |
| HC-TP-10-1 | Wood | Beta Analytic | AMS | 382410 | TP | 10 | 1 |
| HC-TP-12-1 | Sediment | Beta Analytic | AMS | 382412 | TP | 12 | 1 |
| HC WP1 Tephra #1 | Tephra | Washington State University | Tephra Analysis | - | WP | 1 | 1 |



*Consistent Accuracy . . .
... Delivered On-time*

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Miami, Florida 33155 USA
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Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

June 24, 2014

Mr. Casey Dowling
BGC Engineering, Inc.
8204 104 Street NW, Suite 200
Edmonton, Alberta T6E 4E6
Canada

RE: Radiocarbon Dating Results For Samples EC-TP-9-1, EC-TP-6-2, HC-TP-7-4, HC-TP-8-1 0.5 mbgs, HC-TP-8-3 1.1 mbgs, HC-TP-8-4 3.0 mbgs, J-TP-21 1.6mbgs Charcoal, J-TP-21 1.6mbgs Paleosol, J-TP-21 2.2mbgs, J-TP-21 2.4mbgs Charcoal, J-TP-21 2.4mbgs Tephra

Dear Mr. Dowling:

Enclosed are the radiocarbon dating results for 11 samples recently sent to us. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable. The Conventional Radiocarbon Ages have all been corrected for total fractionation effects and where applicable, calibration was performed using 2013 calibration databases (cited on the graph pages).

The web directory containing the table of results and PDF download also contains pictures, a cvs spreadsheet download option and a quality assurance report containing expected vs. measured values for 3-5 working standards analyzed simultaneously with your samples.

Reported results are accredited to ISO-17025 standards and all chemistry was performed here in our laboratories and counted in our own accelerators here in Miami. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO-17025 program participated in the analyses.

As always Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result.

When interpreting the results, please consider any communications you may have had with us regarding the samples. As always, your inquiries are most welcome. If you have any questions or would like further details of the analyses, please do not hesitate to contact us.

Thank you for prepaying the analyses. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,


Digital signature on file



REPORT OF RADIOCARBON DATING ANALYSES

Mr. Casey Dowling

Report Date: 6/24/2014

BGC Engineering, Inc.

Material Received: 6/11/2014

| Sample Data | Measured Radiocarbon Age | 13C/12C Ratio | Conventional Radiocarbon Age(*) |
|---|--------------------------|---------------|---------------------------------|
| Beta - 382778 SAMPLE : EC-TP-9-1 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 380 to 200 (Cal BP 2330 to 2150) | 2190 +/- 30 BP | -23.3 o/oo | 2220 +/- 30 BP |
| Beta - 382779 SAMPLE : EC-TP-6-2 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali 2 SIGMA CALIBRATION : Cal AD 255 to 295 (Cal BP 1695 to 1655) and Cal AD 320 to 415 (Cal BP 1630 to 1535) | 1600 +/- 30 BP | -19.5 o/oo | 1690 +/- 30 BP |
| Beta - 382780 SAMPLE : HC-TP-7-4 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali 2 SIGMA CALIBRATION : Cal BC 380 to 200 (Cal BP 2330 to 2150) | 2120 +/- 30 BP | -18.6 o/oo | 2220 +/- 30 BP |
| Beta - 382781 SAMPLE : HC-TP-8-1 0.5 mbgs ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali 2 SIGMA CALIBRATION : Cal AD 1020 to 1155 (Cal BP 930 to 795) | 860 +/- 30 BP | -19.1 o/oo | 960 +/- 30 BP |

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "**". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.



REPORT OF RADIOCARBON DATING ANALYSES

Mr. Casey Dowling

Report Date: 6/24/2014

| Sample Data | Measured Radiocarbon Age | 13C/12C Ratio | Conventional Radiocarbon Age(*) |
|--|--------------------------|---------------|---------------------------------|
| Beta - 382782 SAMPLE : HC-TP-8-3 1.1 mbgs ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali 2 SIGMA CALIBRATION : Cal BC 395 to 350 (Cal BP 2345 to 2300) and Cal BC 305 to 210 (Cal BP 2255 to 2160) | 2120 +/- 30 BP | -16.5 o/oo | 2260 +/- 30 BP |
| Beta - 382783 SAMPLE : HC-TP-8-4 3.0 mbgs ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali 2 SIGMA CALIBRATION : Cal AD 1665 to 1785 (Cal BP 285 to 165) and Cal AD 1795 to 1890 (Cal BP 155 to 60) and Cal AD 1905 to Post 1950 (Cal BP 45 to Post 0) | 80 +/- 30 BP | -20.7 o/oo | 150 +/- 30 BP |
| Beta - 382784 SAMPLE : J-TP-21 1.6mbgs Charcoal ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 680 to 880 (Cal BP 1270 to 1070) | 1240 +/- 30 BP | -25.3 o/oo | 1240 +/- 30 BP |
| Beta - 382785 SAMPLE : J-TP-21 1.6mbgs Paleosol ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (organic sediment): acid washes 2 SIGMA CALIBRATION : Cal AD 400 to 545 (Cal BP 1550 to 1405) | 1590 +/- 30 BP | -25.1 o/oo | 1590 +/- 30 BP |

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "**". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -19.1 o/oo : lab. mult = 1)

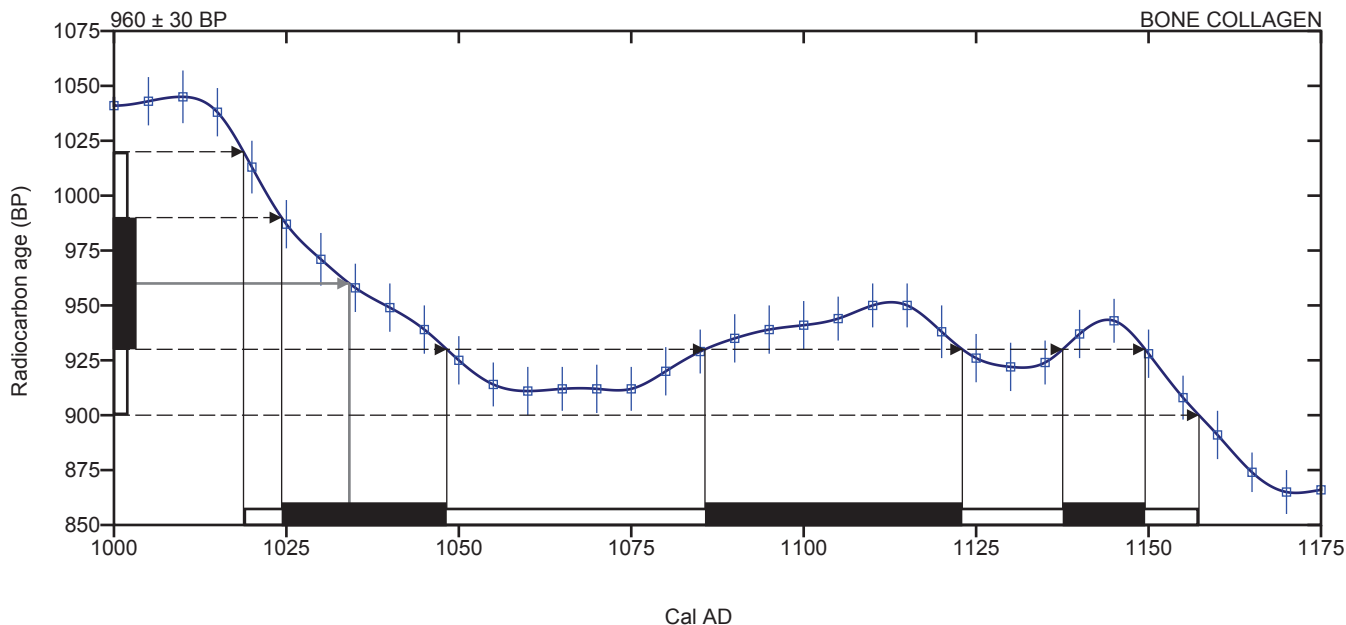
Laboratory number **Beta-382781**

Conventional radiocarbon age **960 ± 30 BP**

2 Sigma calibrated result **Cal AD 1020 to 1155 (Cal BP 930 to 795)**
95% probability

Intercept of radiocarbon age with calibration curve Cal AD 1035 (Cal BP 915)

1 Sigma calibrated results Cal AD 1025 to 1050 (Cal BP 925 to 900)
68% probability Cal AD 1085 to 1125 (Cal BP 865 to 825)
Cal AD 1140 to 1150 (Cal BP 810 to 800)



Database used
INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

References to INTCAL13 database

Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887.

Beta Analytic Radiocarbon Dating Laboratory

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -16.5 o/oo : lab. mult = 1)

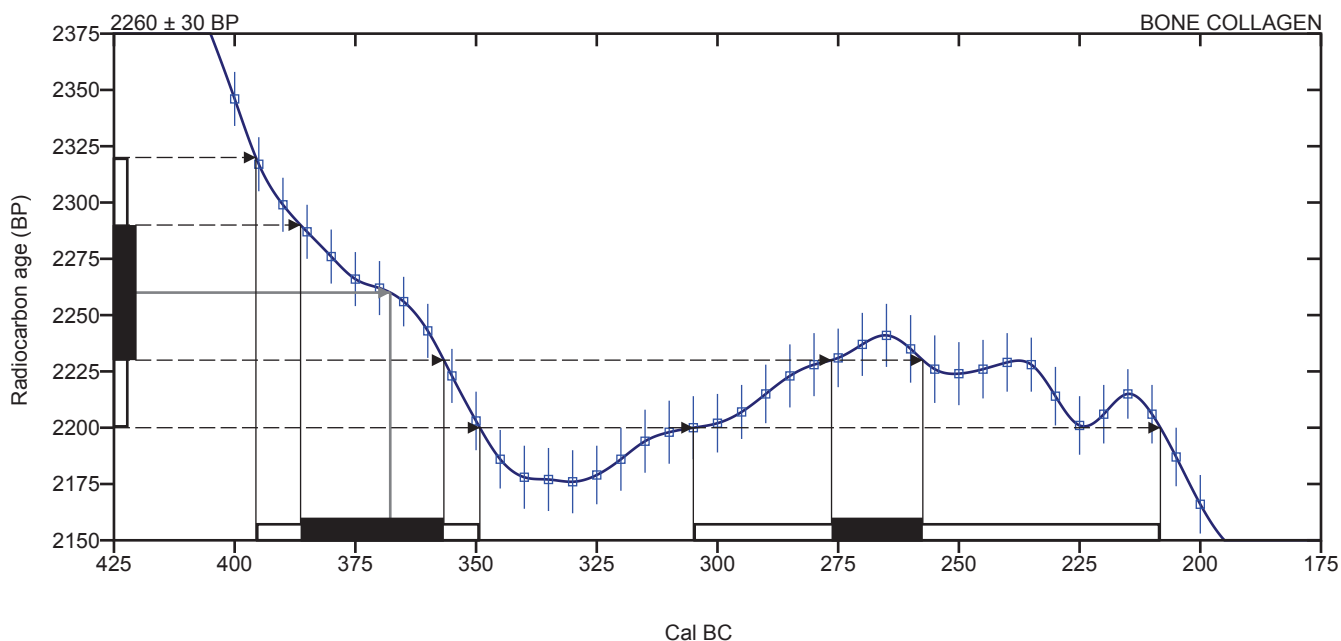
Laboratory number **Beta-382782**

Conventional radiocarbon age **2260 ± 30 BP**

2 Sigma calibrated result **Cal BC 395 to 350 (Cal BP 2345 to 2300)**
95% probability **Cal BC 305 to 210 (Cal BP 2255 to 2160)**

Intercept of radiocarbon age with calibration curve Cal BC 370 (Cal BP 2320)

1 Sigma calibrated results Cal BC 385 to 355 (Cal BP 2335 to 2305)
68% probability Cal BC 275 to 255 (Cal BP 2225 to 2205)



Database used
INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -20.7 o/oo : lab. mult = 1)

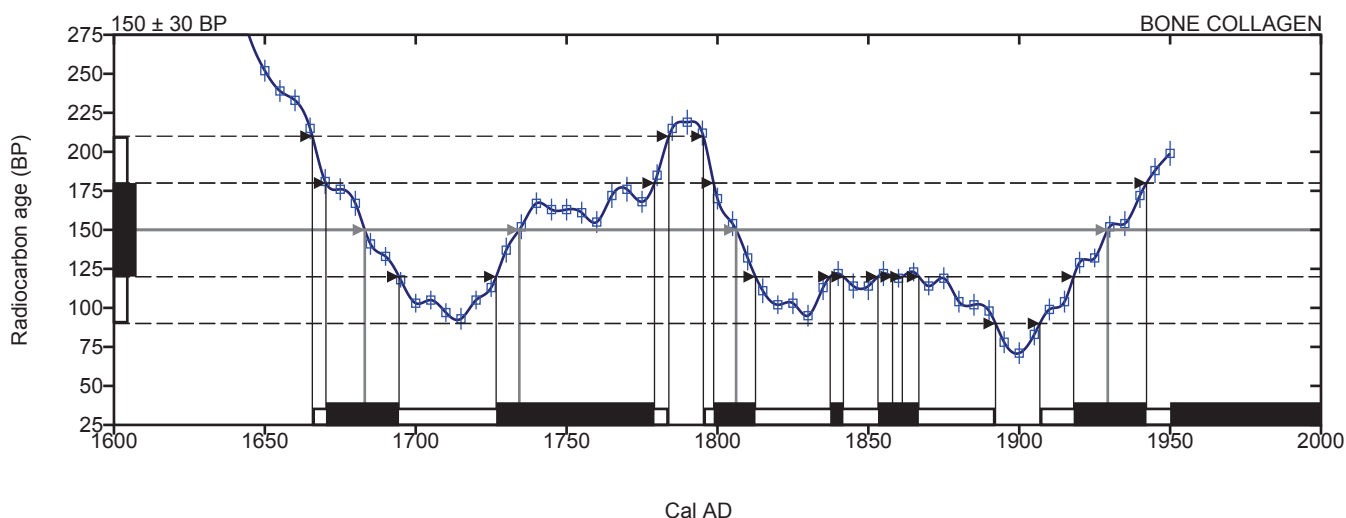
Laboratory number **Beta-382783**

Conventional radiocarbon age **150 ± 30 BP**

2 Sigma calibrated result **Cal AD 1665 to 1785 (Cal BP 285 to 165)**
95% probability **Cal AD 1795 to 1890 (Cal BP 155 to 60)**
Cal AD 1905 to Post 1950 (Cal BP 45 to Post 0)

Intercept of radiocarbon age with calibration curve
Cal AD 1685 (Cal BP 265)
Cal AD 1735 (Cal BP 215)
Cal AD 1805 (Cal BP 145)
Cal AD 1930 (Cal BP 20)
Post AD 1950 (Post BP 0)

1 Sigma calibrated results **Cal AD 1670 to 1695 (Cal BP 280 to 255)**
68% probability **Cal AD 1725 to 1780 (Cal BP 225 to 170)**
Cal AD 1800 to 1815 (Cal BP 150 to 135)
Cal AD 1835 to 1840 (Cal BP 115 to 110)
Cal AD 1855 to 1865 (Cal BP 95 to 85)
Cal AD 1920 to 1940 (Cal BP 30 to 10)
Post AD 1950 (Post BP 0)



Database used
INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

References to INTCAL13 database

Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887.

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President

Ronald Hatfield
Christopher Patrick
Deputy Directors

June 26, 2014

Mr. Casey Dowling
BGC Engineering, Inc.
8204 104 Street NW, Suite 200
Edmonton, Alberta T6E 4E6, Canada

RE: Radiocarbon Dating Results For Samples EC-TP-12-1, EC-TP-13-2, EC-TP-17-2, EC-TP-8-1, EC-TP-8-2, EC-TP-8-3, EC-TP-8-4, EC-TP-8-5, EC-TP-14-1, EC-TP-14-2, EC-TP-6-1, HC-WP-1-1, HC-WP-2-Bridge, HC-WP-4-Bridge, HC-WP-4-Org4 (TPX), HC-WP-AP1, HC-TP-1, HC-TP-5-1, HC-TP-7-1, HC-TP-7-2, HC-TP-7-3, HC-TP-10-1, SC-TP-8-Organics Unit 7, SC-TP-14-Paleosol Unit 3, SC-TP-12-Pleisol Unit 8, SC-TP-13-Organic Soil-Unit 6 (0.95m), SC-TP-13-Organic Soil-Unit 10 (1.9m), SW-TP-16-1, SW-TP-13-2, SW-TP-17-2, SW-TP-17-3, SW-TP-6-1, SW-TP-6-2, SW-TP-14-1, SW-TP-14-2, SW-TP-14-3, SW-TP-4-1, SW-TP-11-1, SW-TP-9-1, SW-TP-9-2, SW-TP-7-1, SW-TP-7-2, SW-TP-10-1, SW-TP-10-2, SW-WP-1-1, SW-WP-1-2, SW-WP-1-3, SW-WP-2-1, SW-WP-2-2, SW-WP-3-1, SW-WP-3-2

Dear Mr. Dowling:

Enclosed are the radiocarbon dating results for 51 samples recently sent to us. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable. The Conventional Radiocarbon Ages have all been corrected for total fractionation effects and where applicable, calibration was performed using 2013 calibration databases (cited on the graph pages).

The web directory containing the table of results and PDF download also contains pictures, a cvs spreadsheet download option and a quality assurance report containing expected vs. measured values for 3-5 working standards analyzed simultaneously with your samples.

Reported results are accredited to ISO-17025 standards and all chemistry was performed here in our laboratories and counted in our own accelerators here in Miami. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO-17025 program participated in the analyses.

As always Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result.

When interpreting the results, please consider any communications you may have had with us regarding the samples. As always, your inquiries are most welcome. If you have any questions or would like further details of the analyses, please do not hesitate to contact us.

Thank you for prepaying the analyses. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,


Digital signature on file



REPORT OF RADIOCARBON DATING ANALYSES

Mr. Casey Dowling

Report Date: 6/26/2014

| Sample Data | Measured Radiocarbon Age | 13C/12C Ratio | Conventional Radiocarbon Age(*) |
|---|--------------------------|---------------|---------------------------------|
| Beta - 382393 SAMPLE : EC-TP-14-1 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1275 to 1315 (Cal BP 675 to 635) and Cal AD 1355 to 1390 (Cal BP 595 to 560) | 680 +/- 30 BP | -25.9 o/oo | 670 +/- 30 BP |
| Beta - 382394 SAMPLE : EC-TP-14-2 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1660 to 1695 (Cal BP 290 to 255) and Cal AD 1725 to 1815 (Cal BP 225 to 135) and Cal AD 1835 to 1880 (Cal BP 115 to 70) and Cal AD 1915 to Post 1950 (Cal BP 35 to Post 0) | 170 +/- 30 BP | -24.8 o/oo | 170 +/- 30 BP |
| Beta - 382395 SAMPLE : EC-TP-6-1 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 660 to 770 (Cal BP 1290 to 1180) | 1270 +/- 30 BP | -22.9 o/oo | 1300 +/- 30 BP |
| Beta - 382396 SAMPLE : HC-WP-1-1 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 2875 to 2615 (Cal BP 4825 to 4565) and Cal BC 2605 to 2580 (Cal BP 4555 to 4530) | 4110 +/- 30 BP | -22.9 o/oo | 4140 +/- 30 BP |

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "**". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.



REPORT OF RADIOCARBON DATING ANALYSES

Mr. Casey Dowling

Report Date: 6/26/2014

| Sample Data | Measured Radiocarbon Age | 13C/12C Ratio | Conventional Radiocarbon Age(*) |
|--|--------------------------|---------------|---------------------------------|
| Beta - 382397 SAMPLE : HC-WP-2-Bridge ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1680 to 1765 (Cal BP 270 to 185) and Cal AD 1800 to 1940 (Cal BP 150 to 10) and Post AD 1950 (Post BP 0) | 140 +/- 30 BP | -26.8 o/oo | 110 +/- 30 BP |
| Beta - 382398 SAMPLE : HC-WP-4-Bridge ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1640 to 1670 (Cal BP 310 to 280) and Cal AD 1780 to 1800 (Cal BP 170 to 150) and Cal AD 1940 to Post 1950 (Cal BP 10 to Post 0) | 210 +/- 30 BP | -23.1 o/oo | 240 +/- 30 BP |
| Beta - 382399 SAMPLE : HC-WP-4-Org4 (TPX) ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (organic sediment): acid washes 2 SIGMA CALIBRATION : Cal BC 11525 to 11385 (Cal BP 13475 to 13335) | 11600 +/- 40 BP | -25.4 o/oo | 11590 +/- 40 BP |
| Beta - 382400 SAMPLE : HC-WP-AP1 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1270 to 1305 (Cal BP 680 to 645) and Cal AD 1365 to 1385 (Cal BP 585 to 565) | 670 +/- 30 BP | -24.0 o/oo | 690 +/- 30 BP |

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "**". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.



REPORT OF RADIOCARBON DATING ANALYSES

Mr. Casey Dowling

Report Date: 6/26/2014

| Sample Data | Measured Radiocarbon Age | 13C/12C Ratio | Conventional Radiocarbon Age(*) |
|--|--------------------------|---------------|---------------------------------|
| Beta - 382402 SAMPLE : HC-TP-1 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 395 to 540 (Cal BP 1555 to 1410) | 1580 +/- 30 BP | -24.0 o/oo | 1600 +/- 30 BP |
| Beta - 382403 SAMPLE : HC-TP-5-1 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 475 to 485 (Cal BP 1475 to 1465) and Cal AD 535 to 620 (Cal BP 1415 to 1330) | 1480 +/- 30 BP | -23.8 o/oo | 1500 +/- 30 BP |
| Beta - 382406 SAMPLE : HC-TP-7-1 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1420 to 1465 (Cal BP 530 to 485) | 440 +/- 30 BP | -24.2 o/oo | 450 +/- 30 BP |
| Beta - 382407 SAMPLE : HC-TP-7-2 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 670 to 775 (Cal BP 1280 to 1175) | 1250 +/- 30 BP | -23.5 o/oo | 1270 +/- 30 BP |

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "**". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.



REPORT OF RADIOCARBON DATING ANALYSES

Mr. Casey Dowling

Report Date: 6/26/2014

| Sample Data | Measured Radiocarbon Age | 13C/12C Ratio | Conventional Radiocarbon Age(*) |
|---|--------------------------|---------------|---------------------------------|
| Beta - 382408 SAMPLE : HC-TP-7-3 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 60 to 180 (Cal BP 1890 to 1770) and Cal AD 190 to 215 (Cal BP 1760 to 1735) | 1890 +/- 30 BP | -25.0 o/oo | 1890 +/- 30 BP |
| Beta - 382410 SAMPLE : HC-TP-10-1 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (wood): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1485 to 1650 (Cal BP 465 to 300) | 310 +/- 30 BP | -25.2 o/oo | 310 +/- 30 BP |
| Beta - 382413 SAMPLE : SC-TP-8-Organics Unit 7 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (organic sediment): acid washes 2 SIGMA CALIBRATION : Cal BC 38460 to 37580 (Cal BP 40410 to 39530) | 35430 +/- 210 BP | -27.4 o/oo | 35390 +/- 210 BP |
| Beta - 382414 SAMPLE : SC-TP-14-Paleosol Unit 3 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (organic sediment): acid washes 2 SIGMA CALIBRATION : Cal AD 985 to 1040 (Cal BP 965 to 910) and Cal AD 1110 to 1115 (Cal BP 840 to 835) | 1010 +/- 30 BP | -24.7 o/oo | 1010 +/- 30 BP |

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "**". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -22.9 o/oo : lab. mult = 1)

Laboratory number **Beta-382396**

Conventional radiocarbon age **4140 ± 30 BP**

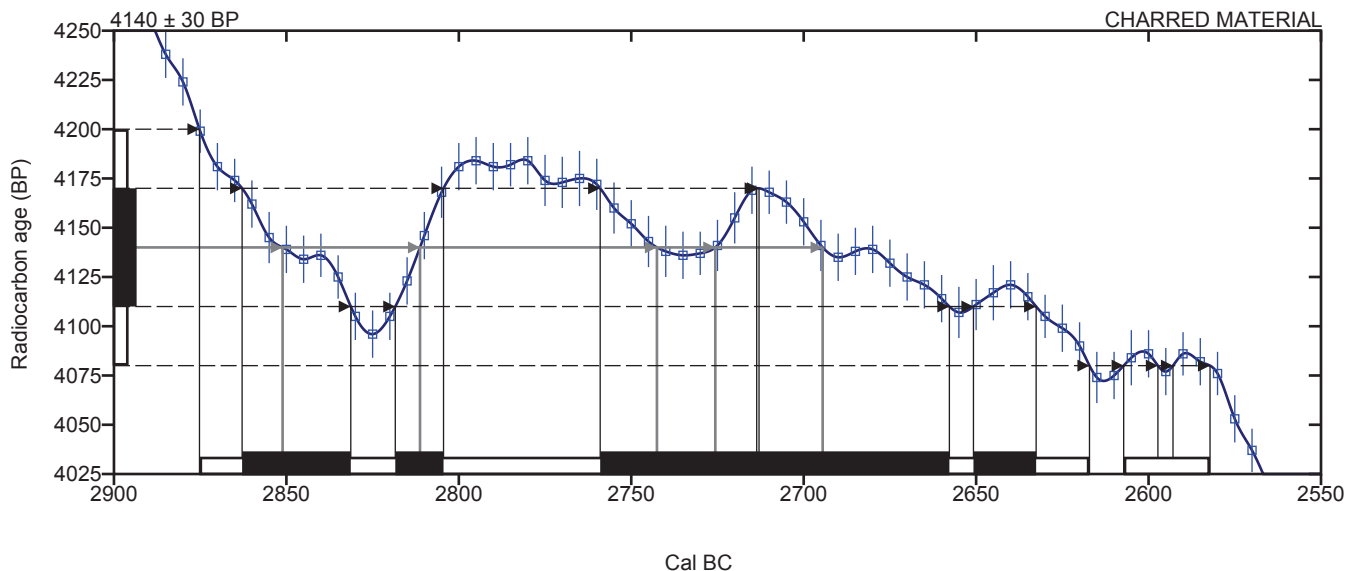
2 Sigma calibrated result **Cal BC 2875 to 2615 (Cal BP 4825 to 4565)**
95% probability **Cal BC 2605 to 2580 (Cal BP 4555 to 4530)**

Intercept of radiocarbon age with calibration curve

| |
|---------------------------|
| Cal BC 2850 (Cal BP 4800) |
| Cal BC 2810 (Cal BP 4760) |
| Cal BC 2745 (Cal BP 4695) |
| Cal BC 2725 (Cal BP 4675) |
| Cal BC 2695 (Cal BP 4645) |

1 Sigma calibrated results

| |
|---|
| Cal BC 2865 to 2830 (Cal BP 4815 to 4780) |
| Cal BC 2820 to 2805 (Cal BP 4770 to 4755) |
| Cal BC 2760 to 2660 (Cal BP 4710 to 4610) |
| Cal BC 2650 to 2635 (Cal BP 4600 to 4585) |



Database used
INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

References to INTCAL13 database

Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887.

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -26.8 o/oo : lab. mult = 1)

Laboratory number **Beta-382397**

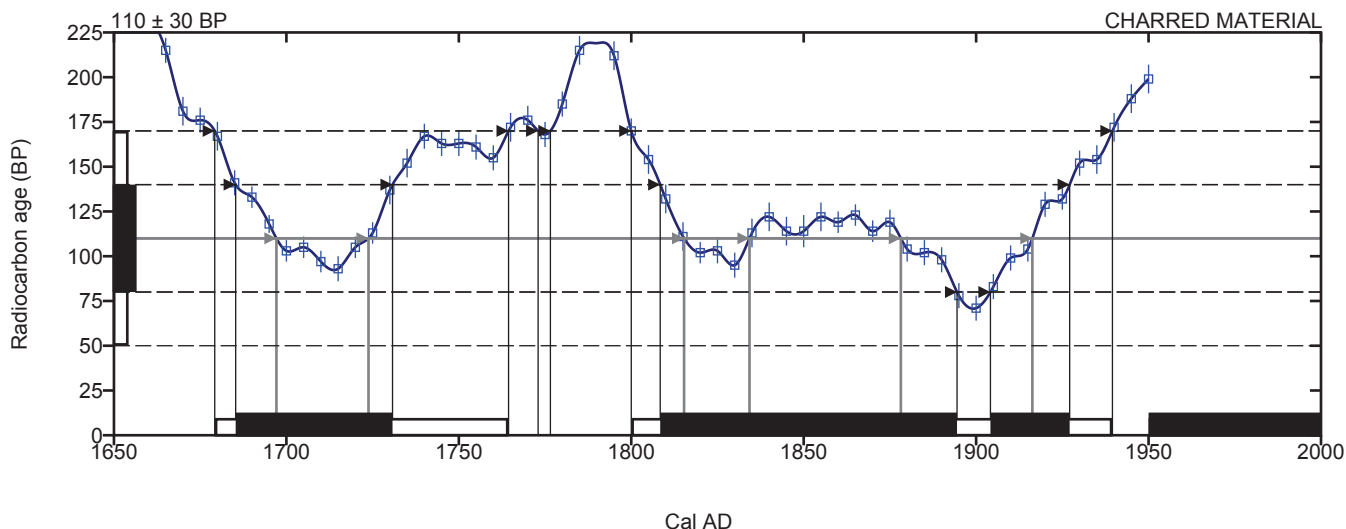
Conventional radiocarbon age **110 ± 30 BP**

2 Sigma calibrated result **Cal AD 1680 to 1765 (Cal BP 270 to 185)**
95% probability **Cal AD 1800 to 1940 (Cal BP 150 to 10)**
 Post AD 1950 (Post BP 0)

Intercept of radiocarbon age with calibration curve

| |
|--------------------------|
| Cal AD 1695 (Cal BP 255) |
| Cal AD 1725 (Cal BP 225) |
| Cal AD 1815 (Cal BP 135) |
| Cal AD 1835 (Cal BP 115) |
| Cal AD 1880 (Cal BP 70) |
| Cal AD 1915 (Cal BP 35) |
| Post AD 1950 (Post BP 0) |

1 Sigma calibrated results **Cal AD 1685 to 1730 (Cal BP 265 to 220)**
68% probability **Cal AD 1810 to 1895 (Cal BP 140 to 55)**
 Cal AD 1905 to 1925 (Cal BP 45 to 25)
 Post AD 1950 (Post BP 0)



Database used
INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

References to INTCAL13 database

Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887.

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -23.1 o/oo : lab. mult = 1)

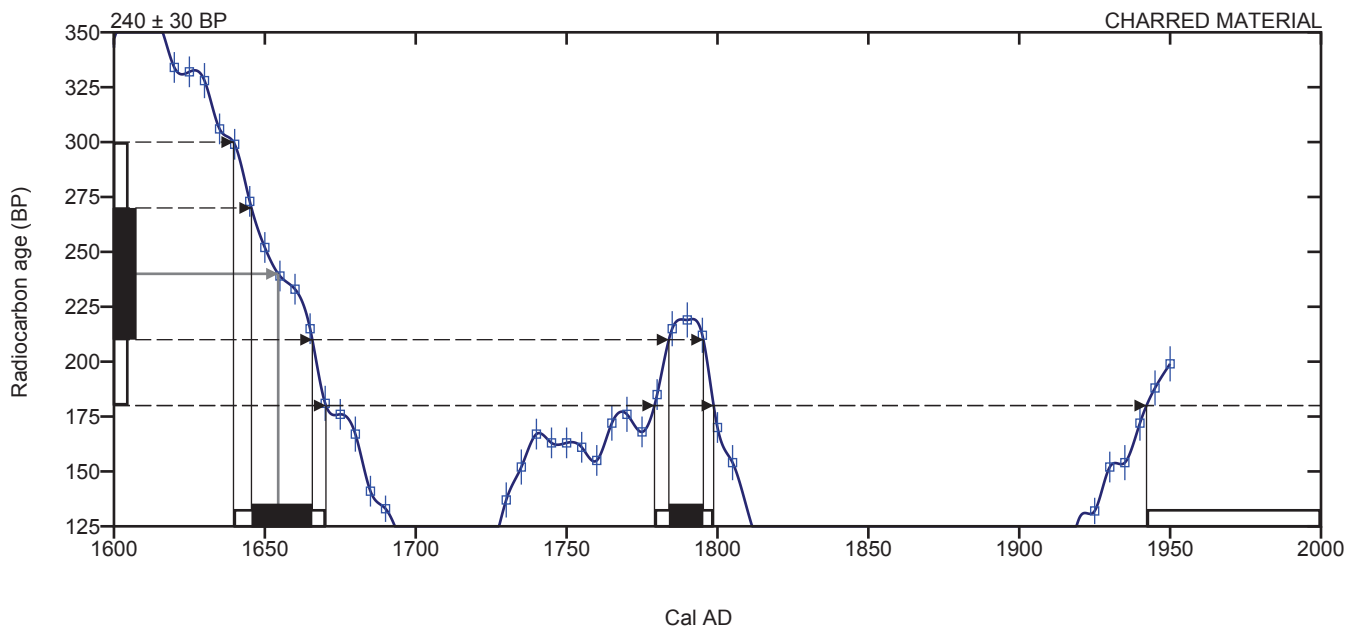
Laboratory number **Beta-382398**

Conventional radiocarbon age **240 ± 30 BP**

2 Sigma calibrated result **95% probability**
Cal AD 1640 to 1670 (Cal BP 310 to 280)
Cal AD 1780 to 1800 (Cal BP 170 to 150)
Cal AD 1940 to Post 1950 (Cal BP 10 to Post 0)

Intercept of radiocarbon age with calibration curve **Cal AD 1655 (Cal BP 295)**

1 Sigma calibrated results **68% probability**
Cal AD 1645 to 1665 (Cal BP 305 to 285)
Cal AD 1785 to 1795 (Cal BP 165 to 155)



Database used
INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

References to INTCAL13 database

Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887.

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -25.4 o/oo : lab. mult = 1)

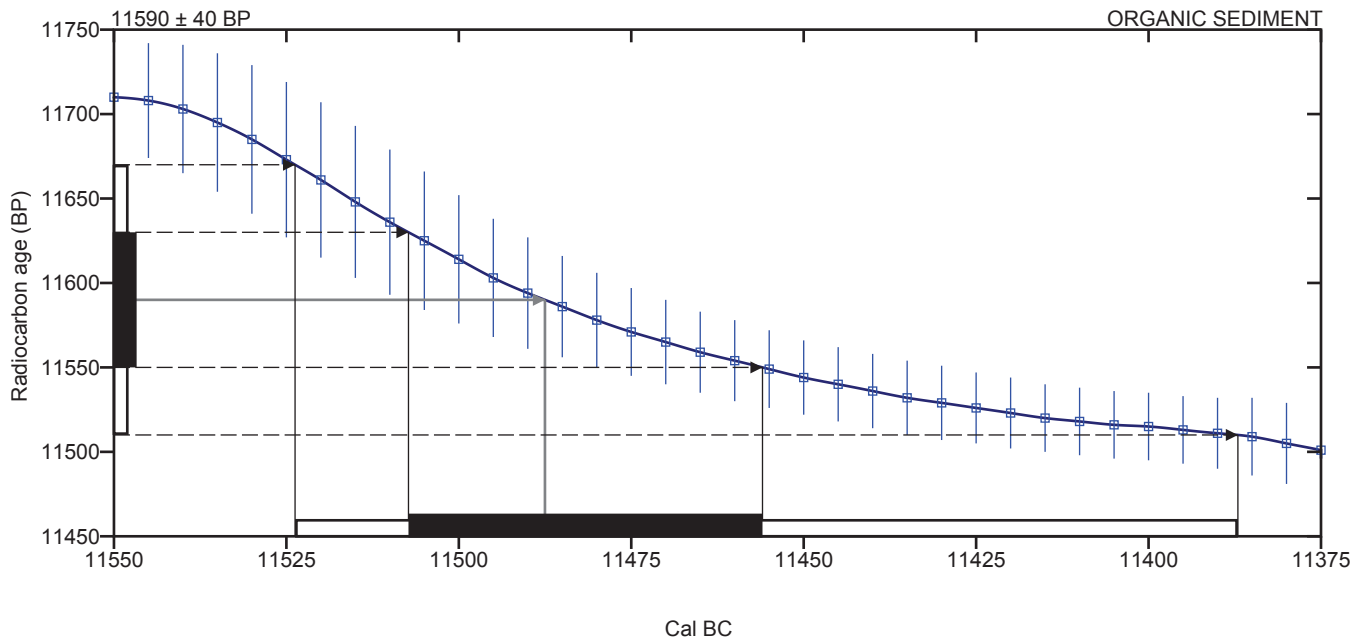
Laboratory number **Beta-382399**

Conventional radiocarbon age **11590 ± 40 BP**

2 Sigma calibrated result **Cal BC 11525 to 11385 (Cal BP 13475 to 13335)**
95% probability

Intercept of radiocarbon age with calibration curve Cal BC 11490 (Cal BP 13440)

1 Sigma calibrated results Cal BC 11505 to 11455 (Cal BP 13455 to 13405)
68% probability



Database used
INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

References to INTCAL13 database

Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887.

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -24 o/oo : lab. mult = 1)

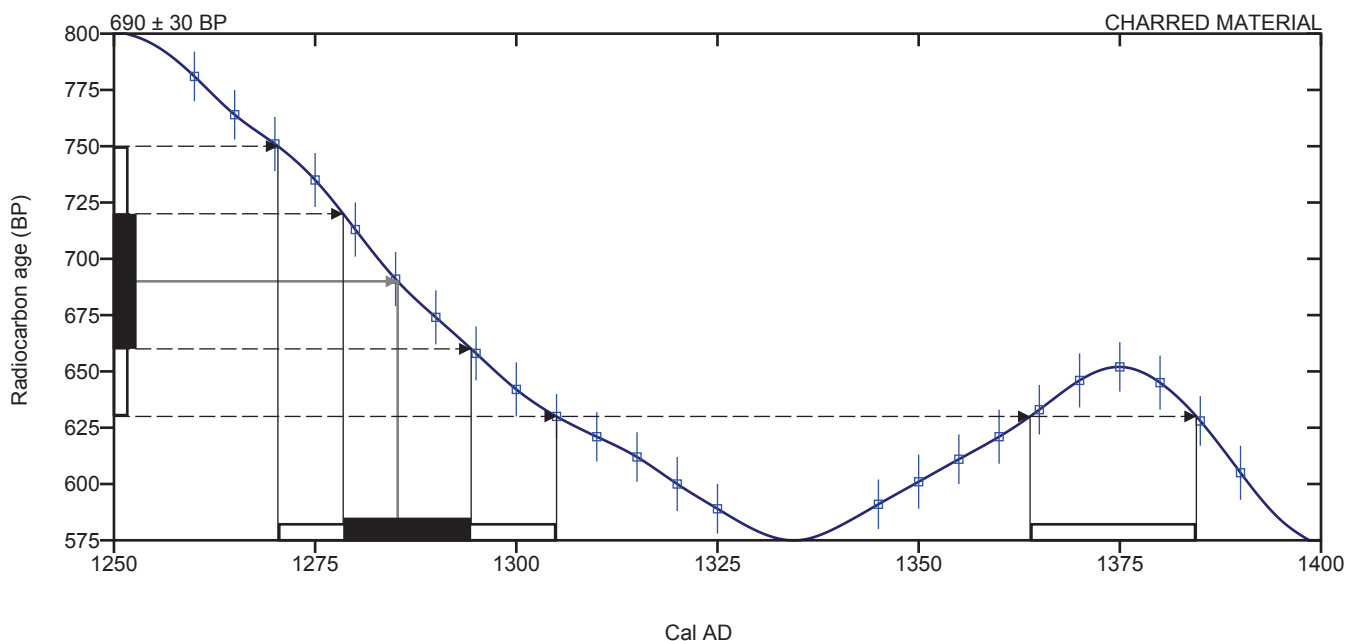
Laboratory number **Beta-382400**

Conventional radiocarbon age **690 ± 30 BP**

2 Sigma calibrated result **Cal AD 1270 to 1305 (Cal BP 680 to 645)**
95% probability **Cal AD 1365 to 1385 (Cal BP 585 to 565)**

Intercept of radiocarbon age with calibration curve Cal AD 1285 (Cal BP 665)

1 Sigma calibrated results Cal AD 1280 to 1295 (Cal BP 670 to 655)
68% probability



Database used
INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

References to INTCAL13 database

Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887.

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -24 ‰ : lab. mult = 1)

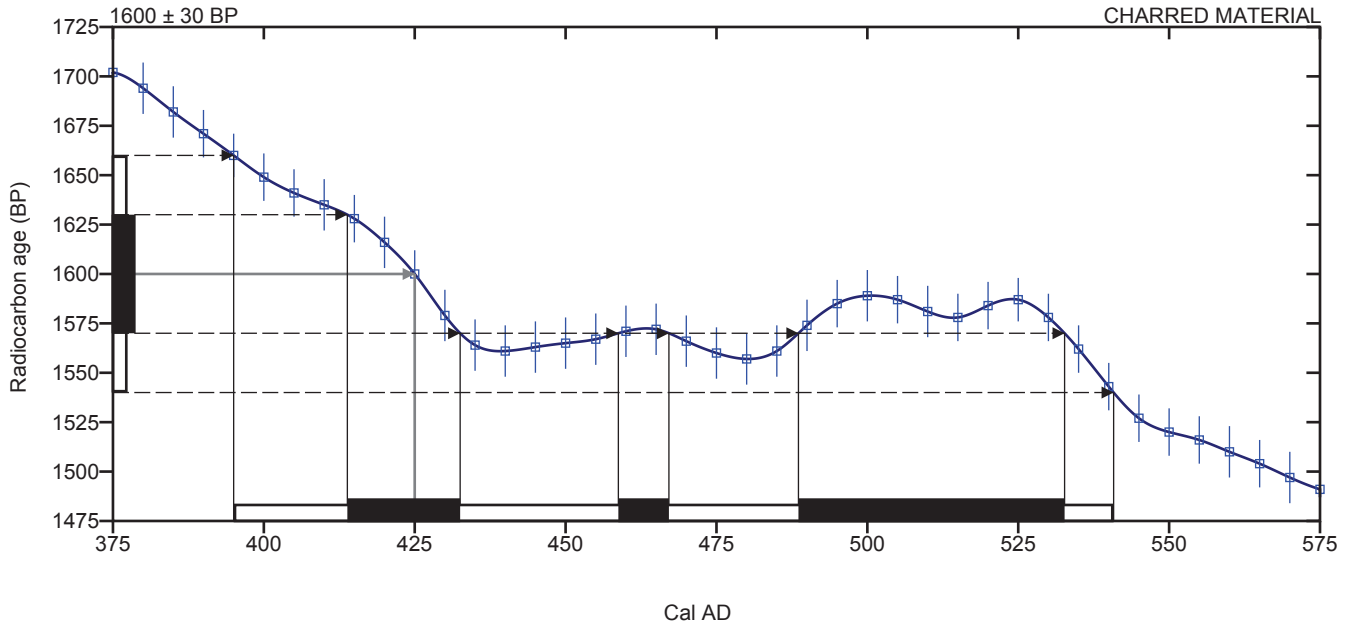
Laboratory number **Beta-382402**

Conventional radiocarbon age **1600 ± 30 BP**

2 Sigma calibrated result **Cal AD 395 to 540 (Cal BP 1555 to 1410)**
95% probability

Intercept of radiocarbon age with calibration curve Cal AD 425 (Cal BP 1525)

1 Sigma calibrated results Cal AD 415 to 435 (Cal BP 1535 to 1515)
68% probability Cal AD 460 to 465 (Cal BP 1490 to 1485)
Cal AD 490 to 535 (Cal BP 1460 to 1415)



Database used
INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

References to INTCAL13 database

Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887.

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -23.8 o/oo : lab. mult = 1)

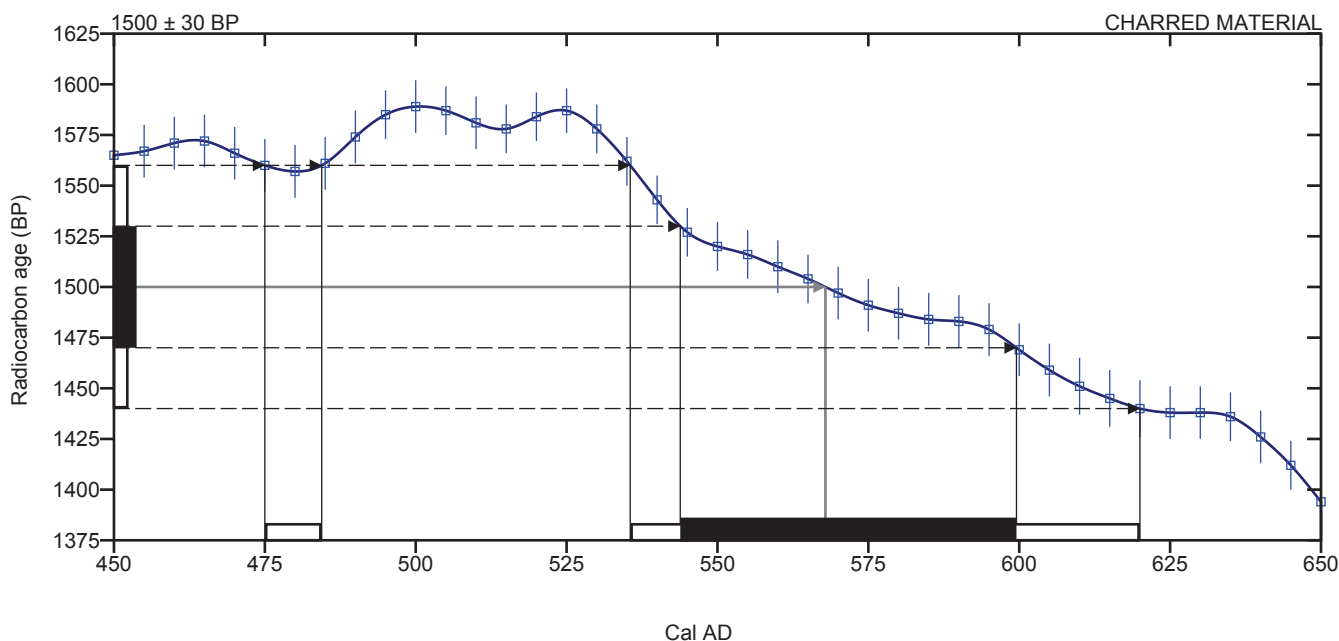
Laboratory number **Beta-382403**

Conventional radiocarbon age **1500 ± 30 BP**

2 Sigma calibrated result **Cal AD 475 to 485 (Cal BP 1475 to 1465)**
95% probability **Cal AD 535 to 620 (Cal BP 1415 to 1330)**

Intercept of radiocarbon age with calibration curve Cal AD 570 (Cal BP 1380)

1 Sigma calibrated results Cal AD 545 to 600 (Cal BP 1405 to 1350)
68% probability



Database used
INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

References to INTCAL13 database

Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887.

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -24.2 o/oo : lab. mult = 1)

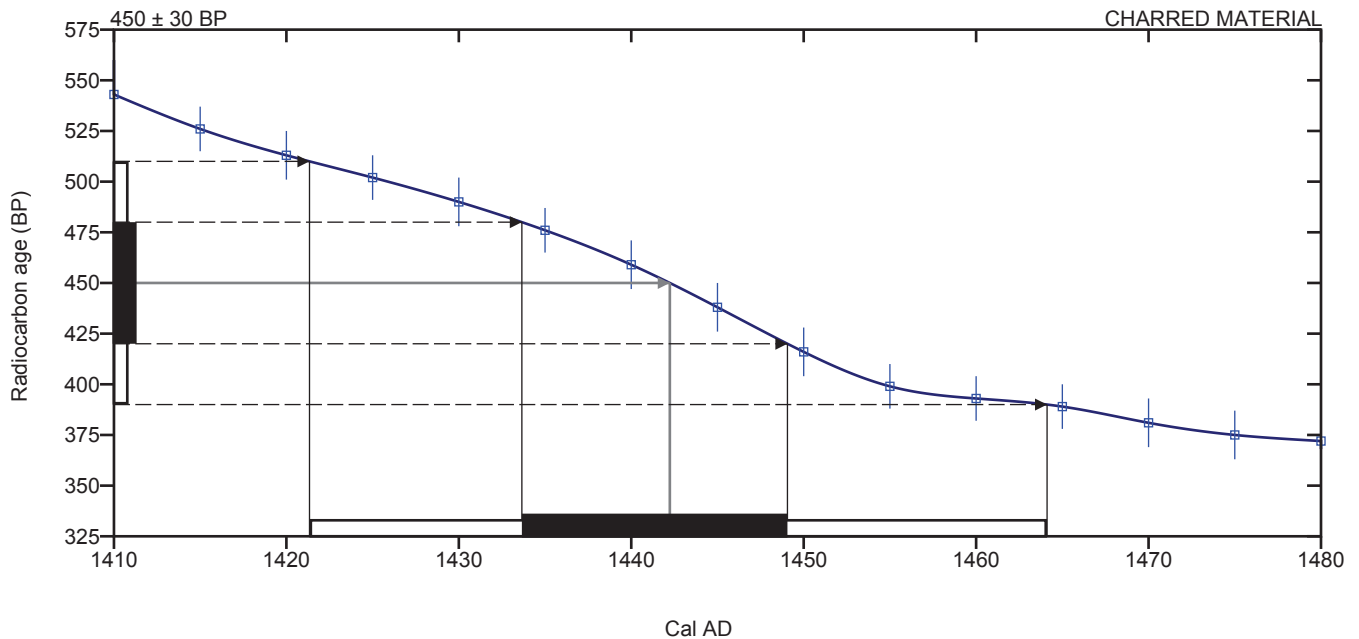
Laboratory number **Beta-382406**

Conventional radiocarbon age **450 ± 30 BP**

2 Sigma calibrated result **Cal AD 1420 to 1465 (Cal BP 530 to 485)**
95% probability

Intercept of radiocarbon age with calibration curve Cal AD 1440 (Cal BP 510)

1 Sigma calibrated results **Cal AD 1435 to 1450 (Cal BP 515 to 500)**
68% probability



Database used
INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

References to INTCAL13 database

Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887.

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -25.2 o/oo : lab. mult = 1)

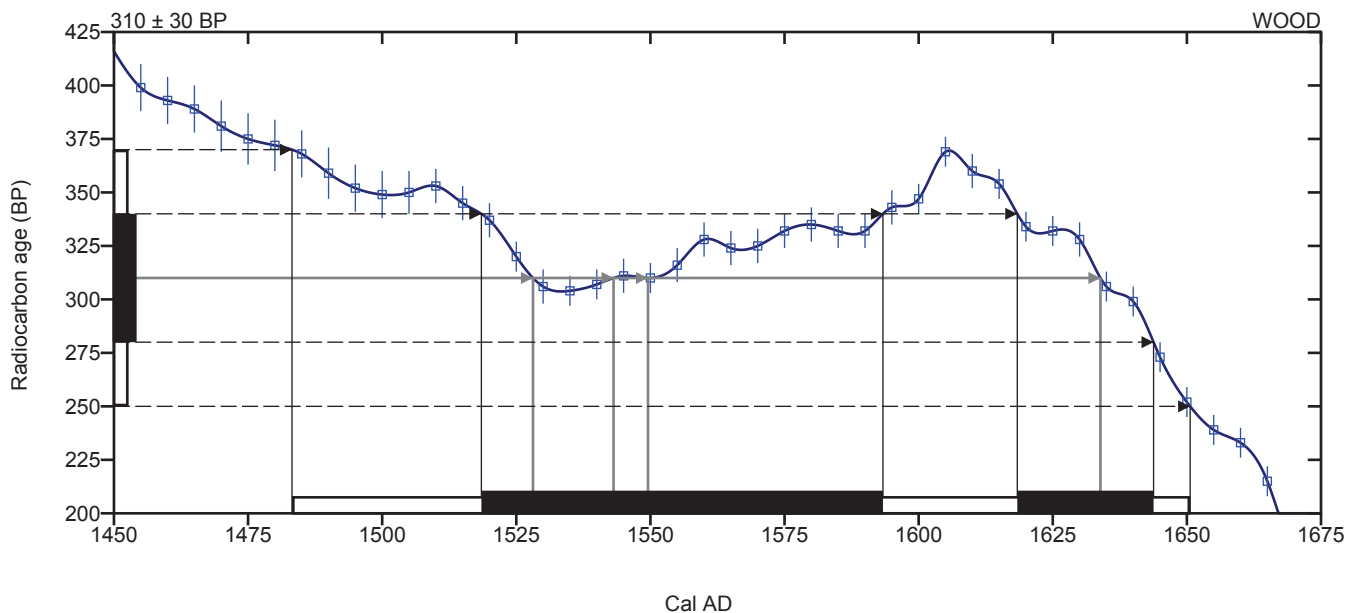
Laboratory number **Beta-382410**

Conventional radiocarbon age **310 ± 30 BP**

2 Sigma calibrated result **Cal AD 1485 to 1650 (Cal BP 465 to 300)**
95% probability

Intercept of radiocarbon age with calibration curve
Cal AD 1530 (Cal BP 420)
Cal AD 1545 (Cal BP 405)
Cal AD 1550 (Cal BP 400)
Cal AD 1635 (Cal BP 315)

1 Sigma calibrated results **Cal AD 1520 to 1595 (Cal BP 430 to 355)**
68% probability **Cal AD 1620 to 1645 (Cal BP 330 to 305)**



Database used
INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

References to INTCAL13 database

Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887.

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Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

August 12, 2014

Mr. Casey Dowling
BGC Engineering, Inc.
8204 104 Street NW, Suite 200
Edmonton, Alberta T6E 4E6
Canada

RE: Radiocarbon Dating Result For Sample HC-TP-12-1

Dear Mr. Dowling:

Enclosed is the radiocarbon dating result for one sample recently sent to us. As usual, specifics of the analysis are listed on the report with the result and calibration data is provided where applicable. The Conventional Radiocarbon Age has been corrected for total fractionation effects and where applicable, calibration was performed using 2013 calibration databases (cited on the graph pages).

The web directory containing the table of results and PDF download also contains pictures, a cvs spreadsheet download option and a quality assurance report containing expected vs. measured values for 3-5 working standards analyzed simultaneously with your samples.

The reported result is accredited to ISO-17025 standards and all pretreatments and chemistry were performed here in our laboratories and counted in our own accelerators here in Miami. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO-17025 program participated in the analysis.

As always Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result.

When interpreting the result, please consider any communications you may have had with us regarding the sample. As always, your inquiries are most welcome. If you have any questions or would like further details of the analysis, please do not hesitate to contact us.

The cost of the analysis was charged to the American Express card provided. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Digital signature on file



REPORT OF RADIOCARBON DATING ANALYSES

Mr. Casey Dowling

Report Date: 8/12/2014

BGC Engineering, Inc.

Material Received: 6/6/2014

| Sample Data | Measured Radiocarbon Age | ¹³ C/ ¹² C Ratio | Conventional Radiocarbon Age(*) |
|--|--------------------------|--|---------------------------------|
| Beta - 382412 SAMPLE : HC-TP-12-1 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (organic sediment): acid washes 2 SIGMA CALIBRATION : Cal BC 805 to 770 (Cal BP 2755 to 2720) | 2560 +/- 30 BP | -23.4 o/oo | 2590 +/- 30 BP |

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the ¹⁴C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby ¹⁴C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured ¹³C/¹²C ratios (delta ¹³C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta ¹³C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta ¹³C, the ratio and the Conventional Radiocarbon Age will be followed by "**". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -23.4 o/oo : lab. mult = 1)

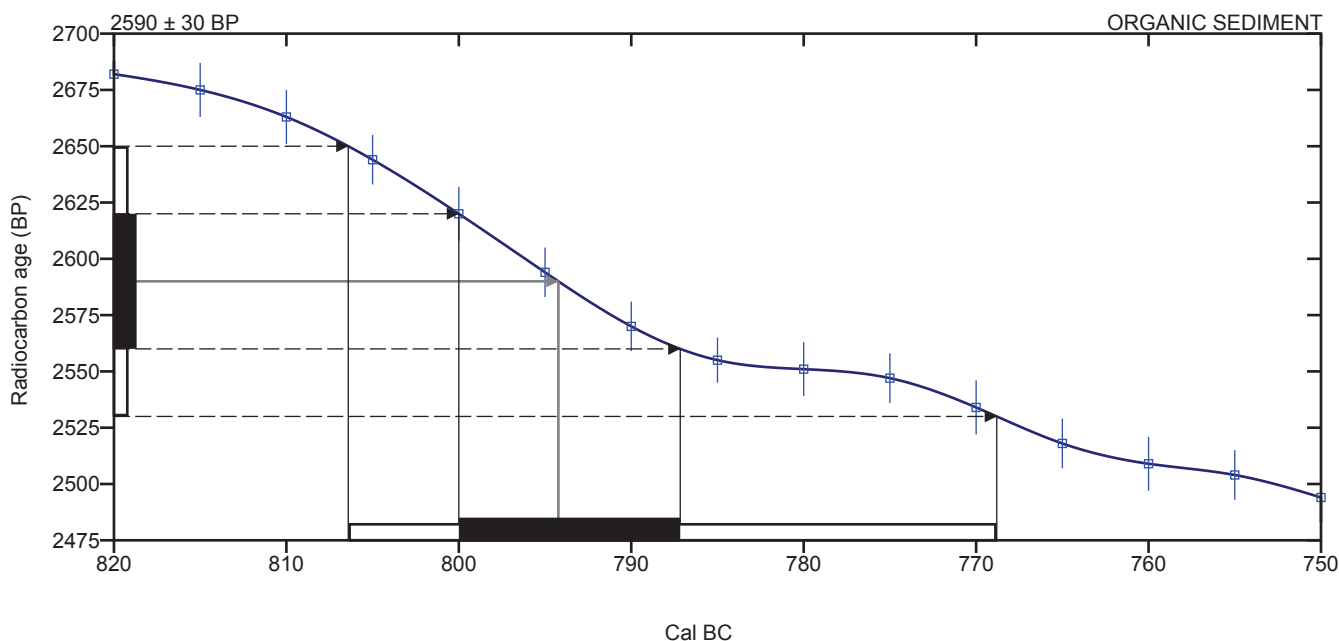
Laboratory number **Beta-382412**

Conventional radiocarbon age **2590 ± 30 BP**

2 Sigma calibrated result **Cal BC 805 to 770 (Cal BP 2755 to 2720)**
95% probability

Intercept of radiocarbon age with calibration curve Cal BC 795 (Cal BP 2745)

1 Sigma calibrated results Cal BC 800 to 785 (Cal BP 2750 to 2735)
68% probability



Database used
INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

References to INTCAL13 database

Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887.

Beta Analytic Radiocarbon Dating Laboratory

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June 3, 2014

Mr. Casey Dowling
Geological Engineer
BGC Engineering Inc
Suite 200 – 8204 – 104 Street NW
Edmonton, AB, CAN, T6E 4E6

Dear Mr. Dowling:

I have enclosed the analytical results on the two samples (HC WP1, tephra #1 and SW-T-4, unit 9) you provided our laboratory for analysis. The composition of the volcanic glass in both samples is an excellent match (similarity coefficient = 0.99) to glass in well-documented samples of tephra from the 6730 ± 40 ^{14}C BP climactic eruption of Mount Mazama.

I trust this information will prove useful in your work and thank you for using our service. If you have any questions please do not hesitate to call (509-335-3093) or email (fffoit@gmail.com) me

Sincerely,

Franklin F. (Nick) Foit, Jr.
Professor Emeritus and Director of the Microbeam Lab

TABLE 1. GLASS COMPOSITION/PROBABLE SOURCES OF HEART & STONWORKS CREEK TEPHRAS

| Oxide | Heart Creek HC WP1 Tephra #1 | Stoneworks Creek SW-T-4 Unit 9 |
|-------------------------------------|--|--|
| SiO ₂ | 73.02(0.32) ¹ | 73.07(0.18) |
| Al ₂ O ₃ | 14.66(0.15) | 14.63(0.11) |
| Fe ₂ O ₃ | 2.10(0.04) | 2.10(0.04) |
| TiO ₂ | 0.42(0.04) | 0.43(0.03) |
| Na ₂ O | 4.76(0.24) | 4.73(0.24) |
| K ₂ O | 2.74(0.09) | 2.77(0.07) |
| MgO | 0.47(0.02) | 0.46(0.05) |
| CaO | 1.65(0.10) | 1.62(0.07) |
| Cl | 0.18(0.02) | 0.19(0.02) |
| Total ² | 100 | 100 |
| Number of shards analyzed | 18 | 17 |
| Probable Source/Age | Mazama climactic 6730 +/- 40 ¹⁴ C BP | Mazama climactic 6730 +/- 40 ¹⁴ C BP |
| Similarity Coefficient ³ | 0.99 | 0.99 |

¹ Standard deviations of the analyses given in parentheses

² Analyses normalized to 100 weight percent

³ Borchardt et al. (1972) J. Sed. Petrol., 42, 301-306