



Beta Analytic
TESTING LABORATORY

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ISO/IEC 17025:2005-Accredited Testing Laboratory

February 12, 2019

Dr. Aoife Daly
Dendro DK
Fuglsang Alle 111
Broenshoej, 2700
Denmark

RE: Radiocarbon Dating Results

Dear Dr. Daly,

Enclosed are the radiocarbon dating results for two 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/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators here. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 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. The reported $\delta^{13}C$ values were measured separately in an IRMS (isotope ratio mass spectrometer). They are NOT the AMS $\delta^{13}C$ which would include fractionation effects from natural, chemistry and AMS induced sources.

When interpreting the results, please consider any communications you may have had with us regarding the samples.

Our invoice will be emailed separately. Please forward it to the appropriate officer or send a credit card authorization. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact us.

Sincerely,

Digital signature on file
Ronald E. Hatfield Director



REPORT OF RADIOCARBON DATING ANALYSES

Aoife Daly

Report Date: February 12, 2019

Dendro DK

Material Received: January 23, 2019

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes	
		Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	

Beta - 516637

SH2018.605.029A

440 +/- 30 BP

IRMS δ13C: -26.5 o/oo

(94.0%) 1416 - 1490 cal AD (534 - 460 cal BP)
(1.4%) 1602 - 1610 cal AD (348 - 340 cal BP)

Submitter Material: Woody Material
Pretreatment: (wood) acid/alkali/acid
Analyzed Material: Wood
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 94.67 +/- 0.35 pMC
Fraction Modern Carbon: 0.9467 +/- 0.0035
D14C: -53.30 +/- 3.54 o/oo
Δ14C: -61.17 +/- 3.54 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 470 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.



REPORT OF RADIOCARBON DATING ANALYSES

Aoife Daly

Report Date: February 12, 2019

Dendro DK

Material Received: January 23, 2019

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes	
		Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	

Beta - 516638

SH2018.605.040A

330 +/- 30 BP

IRMS $\delta^{13}C$: -24.3 o/oo

(95.4%)

1477 - 1642 cal AD

(473 - 308 cal BP)

Submitter Material: Woody Material

Pretreatment: (wood) acid/alkali/acid

Analyzed Material: Wood

Analysis Service: AMS-Standard delivery

Percent Modern Carbon: 95.98 +/- 0.36 pMC

Fraction Modern Carbon: 0.9598 +/- 0.0036

D14C: -40.25 +/- 3.58 o/oo

$\Delta^{14}C$: -48.23 +/- 3.58 o/oo(1950:2,019.00)

Measured Radiocarbon Age: (without $\delta^{13}C$ correction): 320 +/- 30 BP

Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the ^{14}C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. $\delta^{13}C$ values are on the material itself (not the AMS $\delta^{13}C$). $\delta^{13}C$ and $\delta^{15}N$ values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: $\delta^{13}C = -26.5$ o/oo)

Laboratory number **Beta-516637**

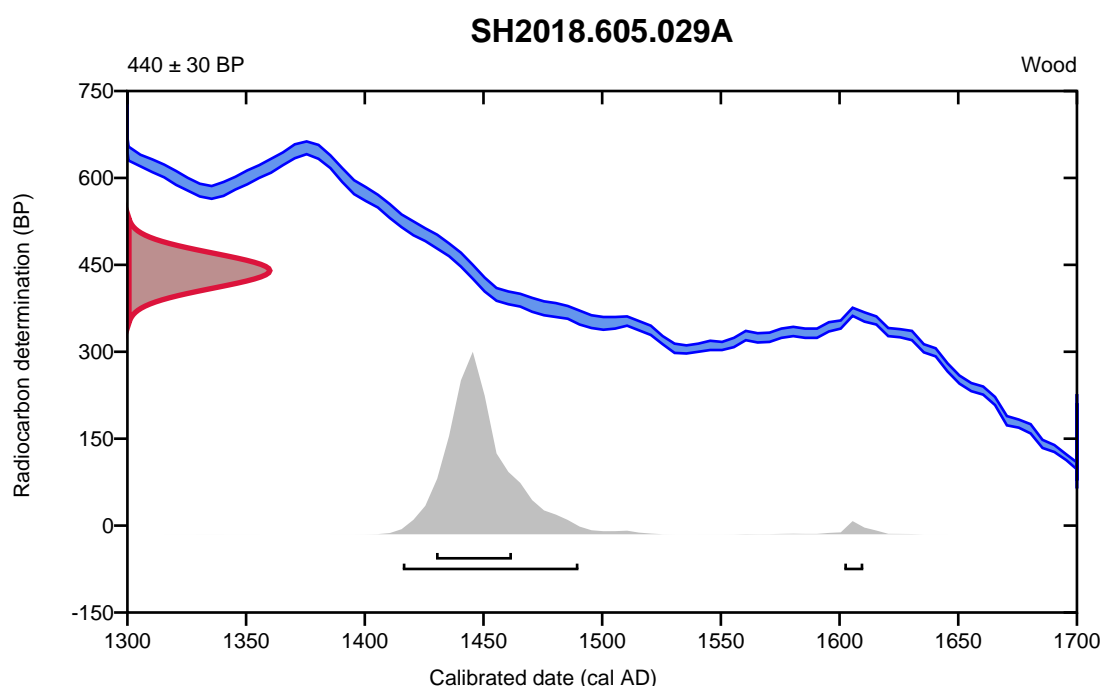
Conventional radiocarbon age **440 ± 30 BP**

95.4% probability

(94%)	1416 - 1490 cal AD	(534 - 460 cal BP)
(1.4%)	1602 - 1610 cal AD	(348 - 340 cal BP)

68.2% probability

(68.2%)	1430 - 1462 cal AD	(520 - 488 cal BP)
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Database used
INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. *Radiocarbon*, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, *Radiocarbon*55(4).

Calibration of Radiocarbon Age to Calendar Years

(highest probability ranges: INTCAL13)

(Variables: $\delta^{13}\text{C} = -24.3$ o/oo)

Laboratory number Beta-516638

Conventional radiocarbon age 330 ± 30 BP

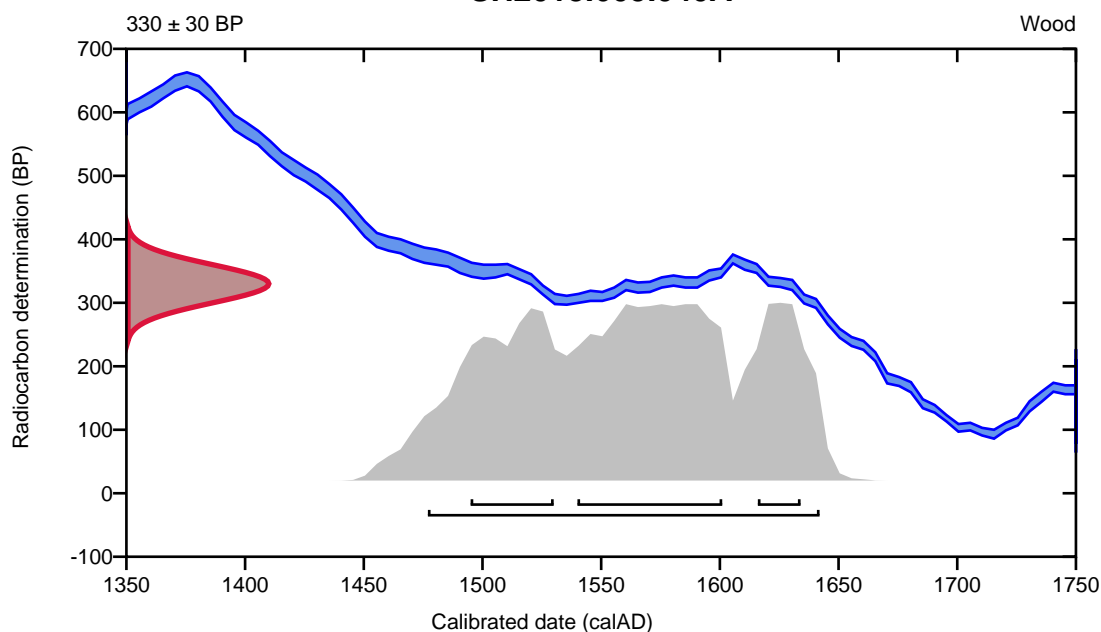
95.4% probability

(95.4%) 1477 - 1642 cal AD (473 - 308 cal BP)

68.2% probability

(37.4%) 1540 - 1601 cal AD (410 - 349 cal BP)
(19%) 1495 - 1530 cal AD (455 - 420 cal BP)
(11.8%) 1616 - 1634 cal AD (334 - 316 cal BP)

SH2018.605.040A



Database used
INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. *Radiocarbon*, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, *Radiocarbon*55(4).



Quality Assurance Report

This report provides the results of reference materials used to validate radiocarbon analyses prior to reporting. Known-value reference materials were analyzed quasi-simultaneously with the unknowns. Results are reported as expected values vs measured values. Reported values are calculated relative to NIST SRM-4990B and corrected for isotopic fractionation. Results are reported using the direct analytical measure percent modern carbon (pMC) with one relative standard deviation. Agreement between expected and measured values is taken as being within 2 sigma agreement (error x 2) to account for total laboratory error.

Report Date: February 12, 2019
Submitter: Dr. Aoife Daly

QA MEASUREMENTS

Reference 1

Expected Value: 0.51 +/-0.04
Measured Value: 0.49 +/- 0.03 pMC
Agreement: Accepted

Reference 2

Expected Value: 129.41 +/- 0.06 pMC
Measured Value: 129.45 +/- 0.35 pMC
Agreement: Accepted

Reference 3

Expected Value: 96.69 +/- 0.50 pMC
Measured Value: 97.34 +/- 0.28 pMC
Agreement: Accepted

COMMENT: All measurements passed acceptance tests.

Validation:


Digital signature on file

Date: February 12, 2019



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TESTING LABORATORY

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ISO/IEC 17025:2005-Accredited Testing Laboratory

March 18, 2019

Dr. Aoife Daly
Dendro DK
Fuglsang Alle 111
Broenshoej, 2700
Denmark

RE: Radiocarbon Dating Results

Dear Dr. Daly,

Enclosed are the radiocarbon dating results for two 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).

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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. The reported $\delta^{13}C$ values were measured separately in an IRMS (isotope ratio mass spectrometer). They are NOT the AMS $\delta^{13}C$ which would include fractionation effects from natural, chemistry and AMS induced sources.

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Sincerely,

Digital signature on file

Chris Patrick Director



ISO/IEC 17025:2005-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

Aoife Daly

Report Date: March 18, 2019

Dendro DK

Material Received: March 08, 2019

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes	
		Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	

Beta - 520554

2018.605.040B

500 +/- 30 BP

IRMS $\delta^{13}C$: -23.5 o/oo

**(94.9%)
(0.5%)**

**1398 - 1449 cal AD
1334 - 1336 cal AD**

**(552 - 501 cal BP)
(616 - 614 cal BP)**

Submitter Material: Woody Material
 Pretreatment: (wood) acid/alkali/acid
 Analyzed Material: Wood
 Analysis Service: AMS-Standard delivery
 Percent Modern Carbon: 93.97 +/- 0.35 pMC
 Fraction Modern Carbon: 0.9397 +/- 0.0035
 D14C: -60.35 +/- 3.51 o/oo
 $\Delta^{14}C$: -68.16 +/- 3.51 o/oo(1950:2,019.00)
 Measured Radiocarbon Age: (without d13C correction): 480 +/- 30 BP
 Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the ^{14}C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. $\delta^{13}C$ values are on the material itself (not the AMS $\delta^{13}C$). $\delta^{13}C$ and $\delta^{15}N$ values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.



REPORT OF RADIOCARBON DATING ANALYSES

Aoife Daly

Report Date: March 18, 2019

Dendro DK

Material Received: March 08, 2019

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes	
		Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	

Beta - 520555	2018.605.029B	560 +/- 30 BP	IRMS δ13C: -24.8 o/oo
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(49.9%)	1307 - 1362 cal AD	(643 - 588 cal BP)
(45.5%)	1385 - 1429 cal AD	(565 - 521 cal BP)

Submitter Material: Woody Material
 Pretreatment: (wood) acid/alkali/acid
 Analyzed Material: Wood
 Analysis Service: AMS-Standard delivery
 Percent Modern Carbon: 93.27 +/- 0.35 pMC
 Fraction Modern Carbon: 0.9327 +/- 0.0035
 D14C: -67.34 +/- 3.48 o/oo
 Δ14C: -75.09 +/- 3.48 o/oo(1950:2,019.00)
 Measured Radiocarbon Age: (without d13C correction): 560 +/- 30 BP
 Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: $\delta^{13}\text{C} = -23.5$ o/oo)

Laboratory number **Beta-520554**

Conventional radiocarbon age **500 ± 30 BP**

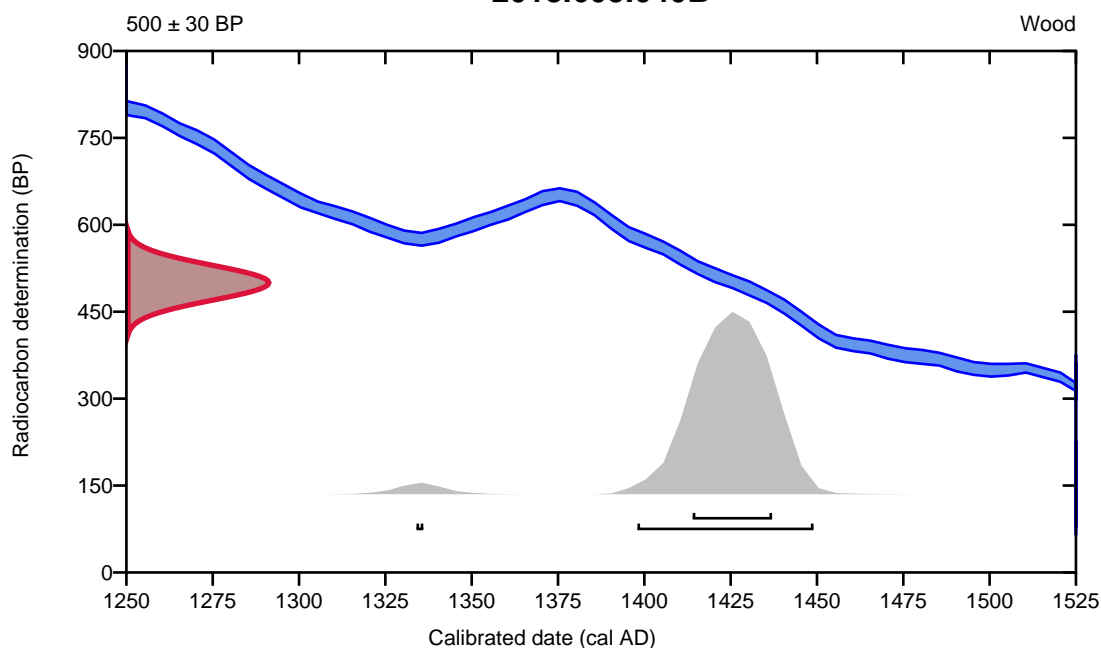
95.4% probability

(94.9%)	1398 - 1449 cal AD	(552 - 501 cal BP)
(0.5%)	1334 - 1336 cal AD	(616 - 614 cal BP)

68.2% probability

(68.2%)	1414 - 1437 cal AD	(536 - 513 cal BP)
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2018.605.040B



Database used
INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. *Radiocarbon*, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, *Radiocarbon*55(4).

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: $\delta^{13}\text{C} = -24.8$ o/oo)

Laboratory number **Beta-520555**

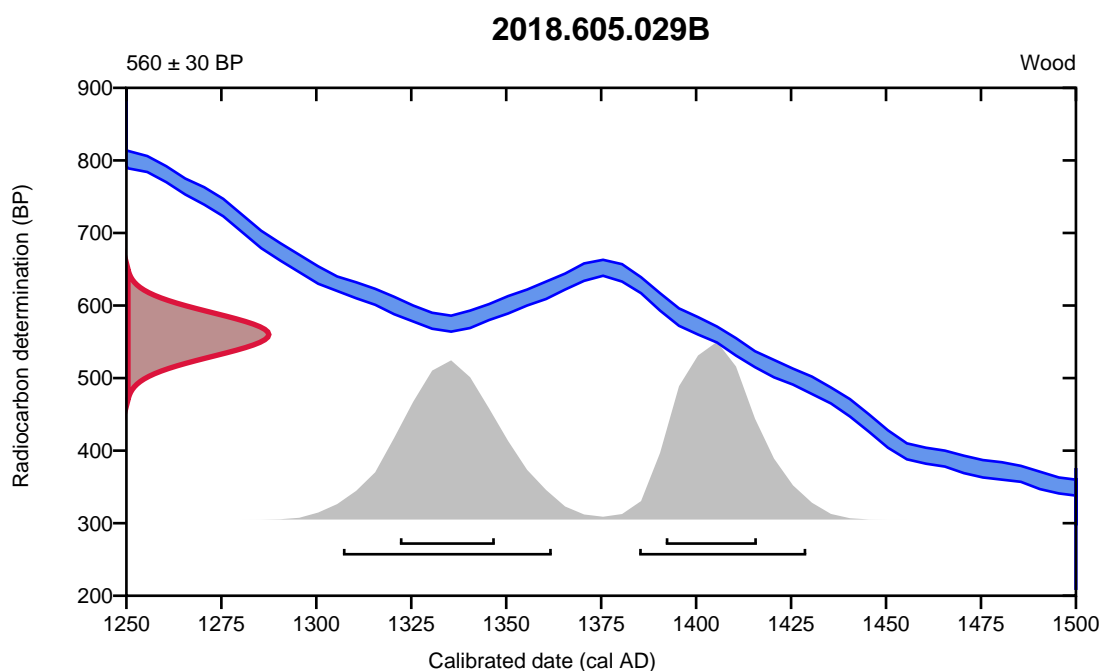
Conventional radiocarbon age **560 ± 30 BP**

95.4% probability

(49.9%)	1307 - 1362 cal AD	(643 - 588 cal BP)
(45.5%)	1385 - 1429 cal AD	(565 - 521 cal BP)

68.2% probability

(34.3%)	1392 - 1416 cal AD	(558 - 534 cal BP)
(33.9%)	1322 - 1347 cal AD	(628 - 603 cal BP)



Database used
INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. *Radiocarbon*, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, *Radiocarbon*55(4).



Quality Assurance Report

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Report Date: March 18, 2019
Submitter: Dr. Aoife Daly

QA MEASUREMENTS

Reference 1

Expected Value: 41.14 +/- 0.10 pMC

Measured Value: 41.28 +/- 0.15 pMC

Agreement: Accepted

Reference 2

Expected Value: 0.51 +/- 0.04

Measured Value: 0.51 +/- 0.03 pMC

Agreement: Accepted

Reference 3

Expected Value: 129.41 +/- 0.06 pMC

Measured Value: 129.51 +/- 0.37 pMC

Agreement: Accepted

COMMENT: All measurements passed acceptance tests.

Validation:


Digital signature on file

Date: March 18, 2019



April 10, 2019

Dr. Aoife Daly
Dendro DK
Fuglsang Alle 111
Broenshoej, 2700
Denmark

RE: Radiocarbon Dating Results

Dear Dr. Daly,

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/IEC 17025:2005 Testing Accreditation PJLA #59423 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/IEC 17025:2005 Testing Accreditation PJLA #59423 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. The reported d13C was measured separately in an IRMS (isotope ratio mass spectrometer). It is NOT the AMS d13C which would include fractionation effects from natural, chemistry and AMS induced sources.

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.

Our invoice has been sent separately. Thank you for your prior efforts in arranging payment. As always, if you have any questions or would like to discuss the results, don't hesitate to contact us.

Sincerely,

Digital signature on file

Chris Patrick Director



REPORT OF RADIOCARBON DATING ANALYSES

Aoife Daly

Report Date: April 10, 2019

Dendro DK

Material Received: April 02, 2019

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes
		Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)

Beta - 522292

2018.605.029c

480 +/- 30 BP

IRMS δ13C: -24.7 o/oo

(95.4%)

1408 - 1452 cal AD

(542 - 498 cal BP)

Submitter Material: Woody Material

Pretreatment: (wood) acid/alkali/acid

Analyzed Material: Wood

Analysis Service: AMS-Standard delivery

Percent Modern Carbon: 94.20 +/- 0.35 pMC

Fraction Modern Carbon: 0.9420 +/- 0.0035

D14C: -58.00 +/- 3.52 o/oo

Δ14C: -65.83 +/- 3.52 o/oo(1950:2,019.00)

Measured Radiocarbon Age: (without d13C correction): 480 +/- 30 BP

Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: $\delta^{13}\text{C} = -24.7$ o/oo)

Laboratory number **Beta-522292**

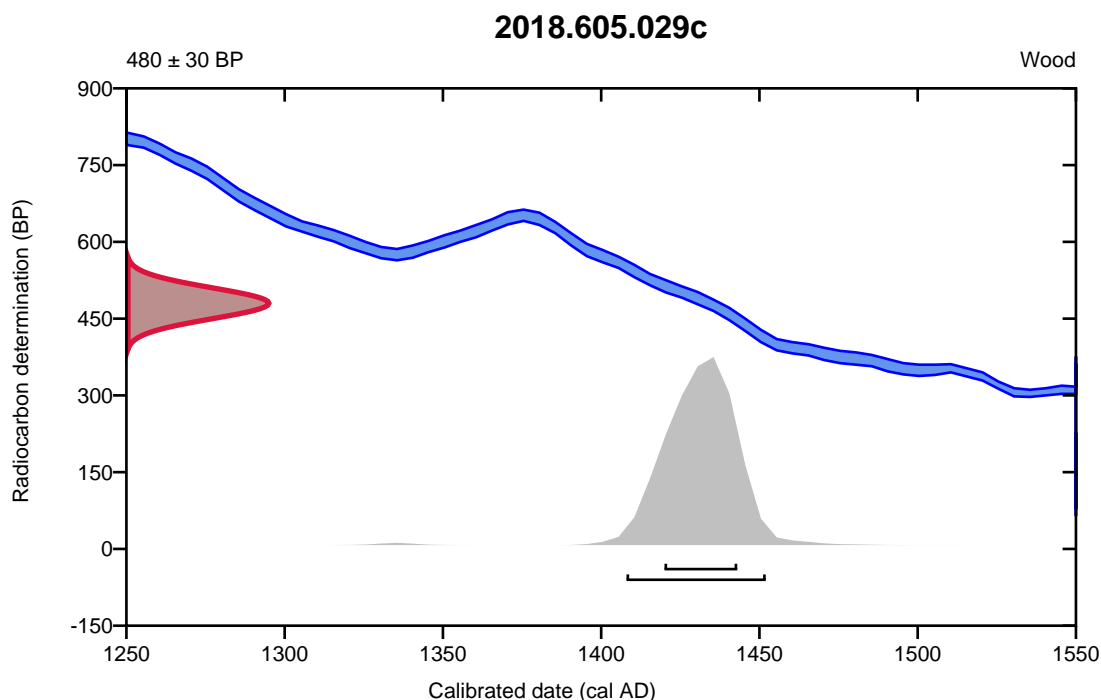
Conventional radiocarbon age **480 ± 30 BP**

95.4% probability

(95.4%) 1408 - 1452 cal AD (542 - 498 cal BP)

68.2% probability

(68.2%) 1420 - 1443 cal AD (530 - 507 cal BP)



Database used
INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. *Radiocarbon*, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, *Radiocarbon*55(4).



Quality Assurance Report

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Report Date: April 10, 2019
Submitter: Dr. Aoife Daly

QA MEASUREMENTS

Reference 1

Expected Value: 0.42 +/- 0.04
Measured Value: 0.42 +/- 0.03 pMC
Agreement: Accepted

Reference 2

Expected Value: 129.41 +/- 0.06 pMC
Measured Value: 129.45 +/- 0.35 pMC
Agreement: Accepted

Reference 3

Expected Value: 96.69 +/- 0.50 pMC
Measured Value: 97.32 +/- 0.28 pMC
Agreement: Accepted

COMMENT: All measurements passed acceptance tests.

Validation:


Digital signature on file

Date: April 10, 2019