Appendix D
Radiocarbon Dates

1. Purpose

- To determine the ages of terraces along the Middle Section of our study reach
- To determine the last time that the channel of the Quinault River (as indicated by gravelly alluvium) was in an area that is now terrace
- To determine the age of the alluvial fan at Finley Creek
- To better understand the geologic history of the Quinault River system

2. Methods

- Twenty samples were collected from the terrace or alluvial-fan deposits (figure 1; attachment 1)
  - Nineteen samples were collected in 2002; one was collected in 2004
  - Sixteen of the samples were bulk sediment samples, some of which contained visible charcoal
    - Samples were from fine-grained (silty sand or sand, primarily) deposits
    - Six samples were from floodplain deposits that overlie gravelly channel deposits beneath terraces
    - Four samples were from sandy beds that interfinger with gravelly alluvium within alluvial-fan deposits at Finley Creek
    - One deposit was from silty beds that may be lacustrine deposits that are exposed on the Finley Creek alluvial fan
    - One deposit was from a silty unit that may be lacustrine deposits that are exposed along the Quinault River near Pruce Boys Road
  - Four samples were from logs that were partially buried in the alluvial deposits; none of these were submitted for dating
    - The logs were embedded in cobbly or gravelly alluvium deposited in the Quinault River channel

- All sixteen of the bulk sediment samples were submitted to Paleo Research Institute (Denver, Colorado) for cleaning, separation, and identification of any charcoal (attachment 2)
  - Of these sixteen samples, two did not contain any charcoal

- Of the remaining fourteen samples that contained enough charcoal for dating, twelve were submitted to Beta Analytic, Inc (Miami, Florida) for radiocarbon dating (attachment 3); charcoal samples that showed rounding (transport) were not submitted for dating
  - Explanation of ages and errors indicated are at the back of Attachement 3

3. Results

- Calibrated radiocarbon ages are shown in Tables 1 and 2, and on Figure 2
- Floral remains that were found in the bulk sediment samples are shown in Tables 2 and 3 in Attachment 2

3.1. Dates Obtained

- Two dates are from floodplain deposits beneath the Upper Surface map unit
    - These samples are from the north side of the Quinault River near RK 7.5
    - These dates range between 660 and 1290 cal years BP (figures 2 and 3, table 2)

- Three dates are from floodplain deposits beneath the Intermediate Surface map unit
    - These samples are from the north side of the Quinault River between RK 11.2 and RK 11.7
    - Two dates range between 540 and 940 cal years BP (figures 2 and 3, table 2)
    - One date from a separate site ranges between 1350 and 1540 cal years BP (figures 2 and 3, table 2)

Two samples are from deposits beneath the Lower Surface map unit
- One of these is from floodplain deposits on the north side of the Quinault River near RK 11.7
- The date for this sample is $\leq$430 cal years BP (figures 2 and 3, table 2)
- One of these is from a silty deposit that may be a lacustrine unit exposed beneath the Lower Surface on the south side of the Quinault River near RK 2.3
- The date obtained from this unit is 930 to 1060 cal years BP (figures 2 and 3, table 2)

- Four samples are from alluvial-fan deposits exposed near the toe of the Finley Creek alluvial-fan complex
    - The results from these samples range between 2350 and 4220 cal years BP (figures 2 and 3, table 2)

- One sample is from silty beds exposed along Finley Creek about 0.5 km downstream from the bridge. These deposits may be lacustrine deposits.
    - The date from this sample is between 6300 and 6500 cal years BP (figures 2 and 3, table 2)

3.2. Relationship Between Dates, Map Units, and Location Along the Quinault River

- Dates from the alluvial-fan deposits are older and are topographically higher than the dates from the surfaces adjacent to the Quinault River.

  - This suggests that the dated terraces are inset into the Finley Creek alluvial fan.

- In general, topographically higher deposits yield older dates (figure 4).
  - This would be expected if the Quinault River has been generally downcutting during the last several thousand years.
  - The date from the Lower Surface near RK 11.7 is an exception, but may be higher than expected because of local variations in the elevations of the surface or the Quinault River.

- Deeper samples at a single locality or in an area yield younger dates than overlying or higher samples (figure 5).
  - This is the inverse of the relationship that is expected on the basis of the apparent stratigraphic relationships, which suggest that overlying deposits should be younger than underlying deposits

4. Problems In the Interpretations of the Radiocarbon Dates

Several factors may influence the dates obtained

- The dates are limited and widely spaced within the valley. Date are lacking from the south side of the river. It is difficult to interpret the numerous minor surfaces within our map units on the basis of the data

- The locations of the sample sites were determined for most sites with a GPS receiver in the field.
  - The dense trees at some sites, and the sparse satellite coverage at certain times made obtaining a GPS location impossible for some of the sample sites. These sites were located using maps, aerial photographs, and field description of the site. Some of the locations may have considerable error. This is particularly true for Samples 92802-3-1CO and 92802-3-2CO, where the GPS information and field location description did not match. The samples are located as best we could given the information that we had.

- The potential inaccuracies in the locations affect the elevations and heights that have been used.
  - The elevations of the surfaces and the Quinault River (and the derived heights) are from a TIN created in Arc from the 2002 Lidar data.
  - The exact point that is chosen for the location can markedly change the elevation.
  - The elevation data were collected at the study-area scale; the samples were taken at a specific point location.

- The irregularities in the surfaces and in the river also contribute to the errors in the elevations and heights.

- In addition, the elevations were taken from data collected in 2002, and conditions may not have been the same at the time the samples were collected, especially for the sample collected in 2004.

- The samples were collected with the idea of dating the gravelly alluvium, or the time that the channel of the Quinault River last occupied a position under the given surface.
    - Samples were collected from the floodplain deposits that overlie the gravelly alluvium, because the chances of obtaining charcoal were thought to be greater from slower-water (fine-grained) deposits than from the high-energy gravelly alluvium. The goal at the time of sample collection was not dating of the surfaces themselves, which are likely much younger than the dates that we obtained.

- The relationship between depth below the surface and age, which is the inverse of the relationship that is expected on the basis of the apparent stratigraphic relationships is troublesome.
    - Samples that we thought were stratigraphically lower (or older) yielded dates that are younger than higher (or supposedly younger) samples.
    - Several explanations are possible, but they cannot be resolved on the basis of our present work.
        - Older charcoal could be incorporated into the younger floodplain deposits
            - This is a very likely explanation in a dynamic river system, like the Quinault River
            - This calls into question all of the dates that we obtained, even the ones that appear to be stratigraphically correct.
            - The consistency of the older dates always above the younger ones is puzzling, but may be a result of the limited number of samples given the length of the study reach.
        - Inset stratigraphic relationships that were not detected in the field could account for the seemingly older dates from units overlying younger units.
            - This is possible for the alluvial-fan deposits, where discontinuous and irregular cut-and-fill sequences are common.
            - This is a less likely explanation for the layered floodplain deposits underlying the surfaces adjacent to the Quinault River.
        - Some of the samples may have been contaminated with younger carbon and, therefore, yield dates that are younger than the time of deposition
            - Samples were cleaned, and charcoal was separated from the bulk sediment samples in order to minimize contamination by younger organic matter (e.g., roots)
            - Samples closer to the present ground surface might be expected to have a greater chance for contamination (greater chance for

roots, bioturbation), but the samples that are higher stratigraphically yielded older dates than the lower samples

- The dates obtained do not appear to show a strong relationship to our map units.
  - Each map unit includes terraces, or surfaces, at various heights. Our map units are an attempt to distinguish between the main levels of terraces (or surfaces) related to the Quinault River. However, the elevation, or height above the Quinault River, at any single location may vary from the general elevation, or height, of the map unit (figures 6 and 7).
    - The elevations and heights above the Quinault River for each map unit appear to vary across the valley and upstream to downstream (figures 6 and 7).
    - Without additional detailed work in the field, it is difficult to verify correlations.
  - The samples were collected in order to document the time since the active channel of the Quinault River occupied the area beneath the terrace surface (not to determine the age of the surface).
    - The timing of channel occupation several meters below a surface indicated by a map unit is likely highly variable along and across the river for any given surface.
  - The terrace channels (figures 6 and 7) indicate that the surfaces are highly active environments, where flow, incision, and deposition have and continue to occur at regular intervals. Dating deposits in these environments is difficult.

5. Conclusions

- In order to resolve the apparent discrepancies in the radiocarbon dates that we obtained, a more detailed examination of the deposits, stratigraphy, and map units for the reach and at each site is needed, perhaps along with additional radiocarbon dates. These tasks were beyond the scope of our present study. However, the dates can be used in a general interpretation of surface age
- The Lower Surface (the youngest one) is likely younger than 500 years.
  - This is reflected in the ages of trees and other vegetation that are present on this surface.
- The Intermediate Surface and the Upper Surface are difficult to distinguish on the basis of the radiocarbon dates.
  - This is also reflected in the similar elevations of the two surfaces in at least some areas (especially downstream of Big Creek in the Middle Reach) (figures 6, 7, and 8).
  - The lower portions of the floodplain deposits (just above gravelly alluvium) are at least 500 to 1500 years old, in at least some locations. This suggests that the main Quinault River channel has not been in these areas in at least a few hundred to a couple of thousand years.
- The alluvial-fan deposits at Finley Creek are probably at least a few thousand years old.

- Lacustrine deposits may have existed at least two different times in the Quinalt River valley in the Finely Creek area (figure 8).
    - The older lake may date from about 6000 to 6500 years (middle Holocene) or older. (The date is from the upper part of the deposit; however, an angular unconformity indicates at least some portion of the deposits has been removed.)
    - The younger lake may date from about 1000 years and extended upstream from the present Lake Quinault to at least the Pruce Boys Road area (RK 2.3).

Table 1. Ages for Quinault River samples submitted to Beta Analytic, Inc. for radiocarbon analysis

Field sample number	Laboratory sample number	Type of material	C13/C12 ratio	Radiocarbon age (C^{14} yr. BP $\pm$ 1 σ)	Calibrated age range (cal yr. BP $\pm$ 2 σ)
92502-1-2CO	Beta-183376	Conifer charcoal	-24.6	620 $\pm$ 40	660 to 540
92502-1-3PI	Beta-183377	*Picea* charcoal	-26.2	970 $\pm$ 40	940 to 760
92502-2-2CO	Beta-183378	Conifer charcoal	-24.9	1560 $\pm$ 40	1540 to 1350
92502-3-1CO	Beta-183379	Conifer charcoal	-26.4	860 $\pm$ 40	890 to 860; 800 to 680
92502-3-2CO	Beta-183380	Conifer charcoal	-25.5	1300 $\pm$ 40	1290 to 1160
92702-4-1PO	Beta-183381	*Populus* charcoal	-25.5	270 $\pm$ 40	430 to 360; 330 to 280 180 to 150; 10 to 0
92802-3-1CO	Beta-183382	Conifer charcoal	-21.8	3250 $\pm$ 50	3640 to 3400
92802-3-2CO	Beta-183383	Conifer charcoal	-25.0	3720 $\pm$ 40	4220 to 4210; 4170 to 3970
92902-1-1CO	Beta-183384	Conifer charcoal	-26.9	2480 $\pm$ 40	2730 to 2350
92902-1-2CO	Beta-183385	Conifer charcoal	-24.6	3040 $\pm$ 40	3360 to 3150
92902-1-3CO	Beta-183386	Conifer charcoal	-26.5	5650 $\pm$ 50	6500 to 6300
81904-1-1CO	Beta-197492	Conifer charcoal	-23.4	1980 $\pm$ 40	1060 to 930

See the data sheets for the original data from Beta Analytic, Inc. (attachment 3)

Table 2. Radiocarbon ages and geologic setting for Quinault River samples

Field sample number	Radiocarbon age (C^{14} yr. BP ± 1 σ)	Calibrated age range (cal yr. BP ± 2 σ)	Location	Map Unit; Deposit	Type of sediment	Depth Below Surface	Height above gravelly channel alluvium
92502-1-2CO	620 ± 40	660 to 540	North side of Quinault River upstream of Big Creek confluence	Intermediate surface; intermediate floodplain deposit exposed in bank of terrace channel	Sandy silt	89 cm (35 in)	89 cm (35 in)
92502-1-3PI	970 ± 40	940 to 760	North side of Quinault River upstream of Big Creek confluence	Intermediate surface; upper floodplain deposit exposed in bank of terrace channel	Sandy silt	58 cm (23 in)	119 cm (47 in)
92502-2-2CO	1560 ± 40	1540 to 1350	North side of Quinault River upstream of Big Creek confluence	Intermediate surface; upper floodplain deposit exposed in bank of terrace channel along contact with a lower terrace	Sandy silt	76 cm (30 in)	79 cm (31 in)
92502-3-1CO	860 ± 40	890 to 860; 800 to 680	North side of Quinault River upstream of Finley Creek confluence	Upper surface; floodplain deposit exposed in bank of terrace channel	Silt	163 cm (64 in)	107 cm (42 in)
92502-3-2CO	1300 ± 40	1290 to 1160	North side of Quinault River upstream of Finley Creek confluence	Upper surface; floodplain deposit exposed in bank of Quinault River	Silty sand	119 cm (47 in)	10 to 15 cm (4 to 6 in)
92702-4-1PO	270 ± 40	430 to 360; 330 to 280 180 to 150; 10 to 0 (≤430)	North side of Quinault River upstream of Big Creek confluence	Lower surface (about 6 ft above Quinault River); lower floodplain deposit exposed in bank of secondary channel between Big Creek and Quinault River	Silt	66 to 79 cm (26 to 31 in)	2.5 cm (1 in)
92802-3-1CO	3250 ± 50	3640 to 3400	North side of Quinault River upstream of Finley Creek confluence	Alluvial-fan; alluvial-fan deposits exposed in bank along Quinault River; lower sand	Sand	213 to 226 cm (84 to 89 in)	--
92802-3-2CO	3720 ± 40	4220 to 4210; 4170 to 3970	North side of Quinault River upstream of Finley Creek confluence	Alluvial-fan; alluvia-fan deposits exposed in bank along Quinault River; upper sand	Sand	152 to 168 cm (60 to 66 in)	--
92902-1-1CO	2480 ± 40	2730 to 2350	North side of Quinault River upstream of Finley Creek confluence	Alluvial-fan; alluvial-fan deposits exposed in bank along Quinault River	Silt with pebble bed	457 cm (180 in)	--
92902-1-2CO	3040 ± 40	3360 to 3150	North side of Quinault River east of Finley Creek	Alluvial-fan; alluvial-fan deposits exposed in bank along Quinault River	Sand and silt beds	305 cm (120 in)	--
92902-1-3CO	5650 ± 50	6500 to 6300	Finley Creek alluvial fan about 0.5 km downstream of bridge	Alluvial-fan; lacustrine/delta deposit(?) exposed in bank along Finley Creek	Sand and silt beds	213 to 226 cm (84 to 89 in)	--
81904-1-1CO	1080 ± 40	1060 to 930	South side of Quinault River near Pruce Boys Road	Lower surface; lacustrine deposit(?) exposed in bank along Quinault River	Silt	260 cm (101 in)	>40 cm (>16 in)

See the data sheets for the original data from Beta Analytic, Inc. (attachment 3)

Table 3. Elevations, heights, and depths of sample site along the Quinault River

Map Unit	Site Number	River km 2002	Elevation Site (m)	Elevation River (m)	Height above QR (m)	Minimum Calibrated Age (cal yr BP)	Maximum Calibrated Age (cal yr BP)	Depth below surface (m)	Corrected Elevation (m)	Height Above Gravelly Alluvium (m)
Alluvial Fan	92902-1-3CO	4.4	79.921	67.34	12.581	6300	6500	2.2	77.721	
Alluvial Fan	92902-1-1CO	4.9	74.912	67.34	7.572	2350	2730	4.57	70.342	
Alluvial Fan	92902-1-2CO	4.9	74.912	67.34	7.572	3150	3360	3.05	71.862	
Alluvial Fan	92802-3-1CO	5.2	72.241	67.606	4.635	3400	3640	2.2	70.041	
Alluvial Fan	92802-3-2CO	5.2	72.241	67.606	4.635	3970	4220	1.6	70.641	
Intermediate Surface	92502-1-2CO	11.3	87.445	85.069	2.376	540	660	0.89	86.555	0.89
Intermediate Surface	92502-1-3PI	11.3	87.445	85.069	2.376	760	940	0.58	86.865	1.19
Intermediate Surface	92502-2-2CO	11.5	89.377	85.253	4.124	1350	1540	0.76	88.617	0.79
Upper Surface	92502-3-1CO	7.62	76.764	74.382	2.382	680	890	1.63	75.134	1.07
Upper Surface	92502-3-2CO	7.6	76.532	74.315	2.217	1160	1290	1.19	75.342	0.12
Lower Surface	92702-4-1PO	11.6	89.228	85.382	3.846	0	430	0.73	88.498	0.03
Lower Surface	81904-1-1CO	2.3	62.835	59.458	3.377	930	1060	2.6	60.235	0.4

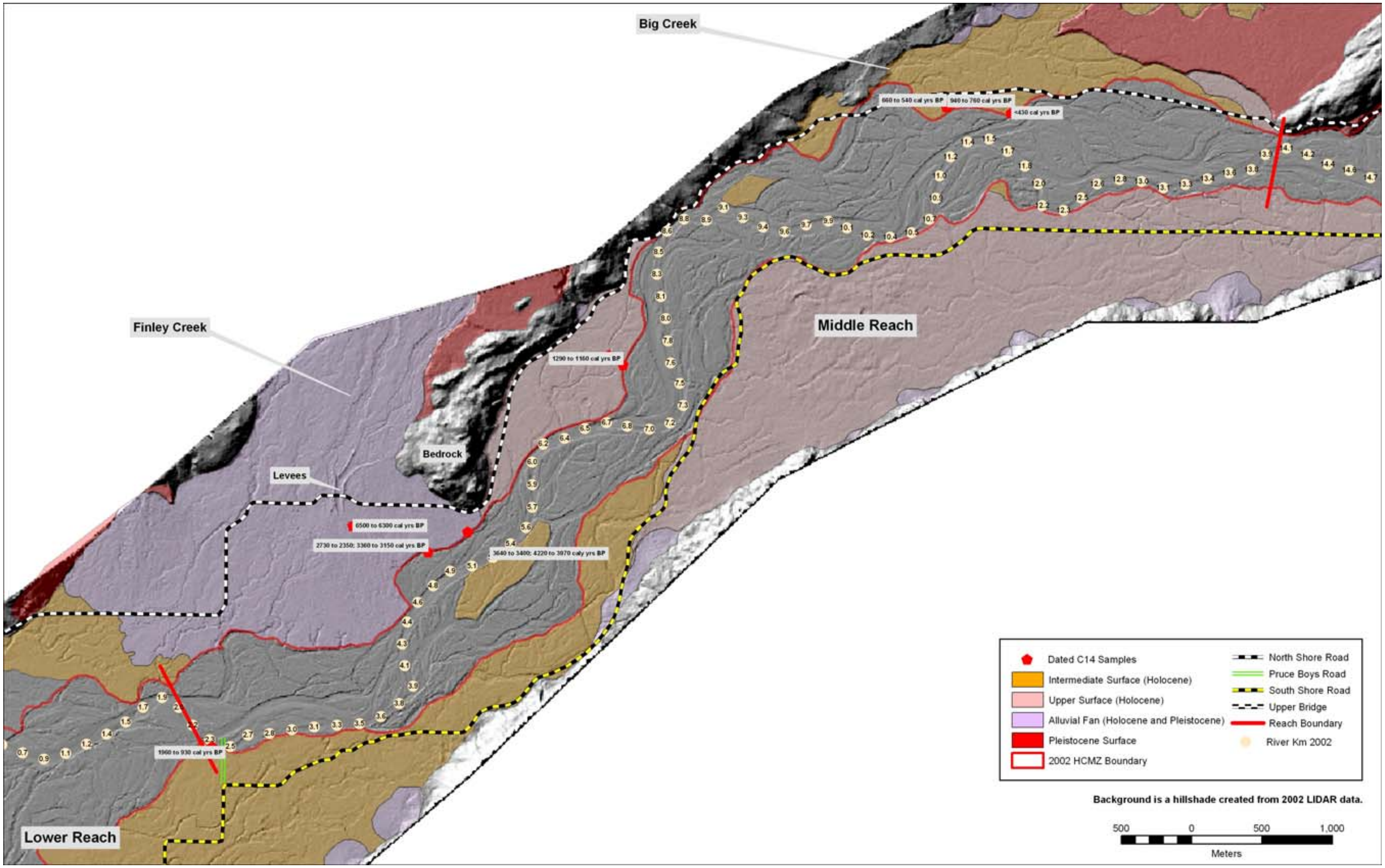

Figure 1. Locations and sample numbers for all of the samples collected for radiocarbon dating along the Middle Reach of the Quinault River. Information on each site is shown in Attachment 1.

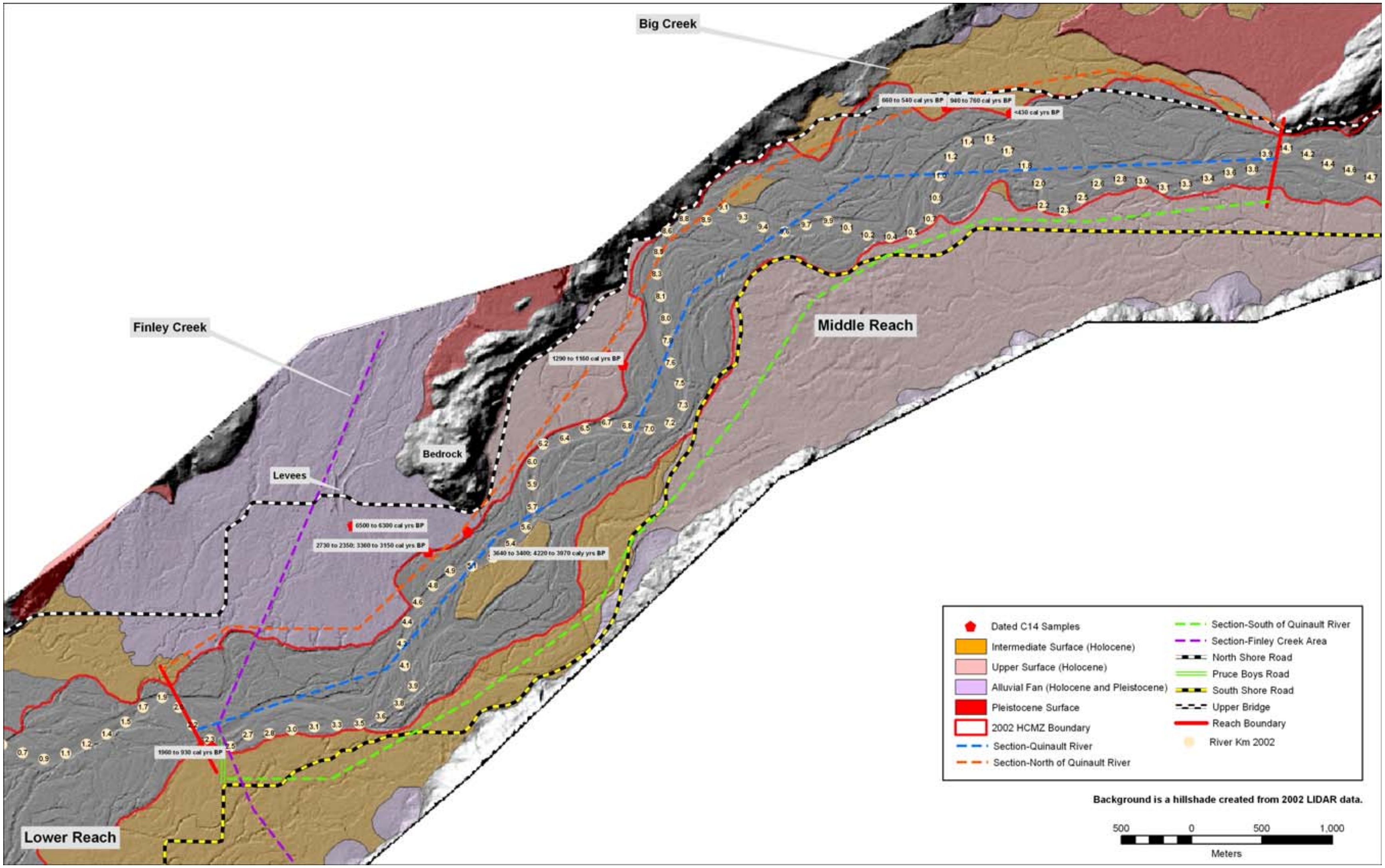

Figure 2. Locations and radiocarbon dates for the twelve samples submitted for radiocarbon dating along the Middle Reach of the Quinault River. Information on the dates is in Tables 1 and 2. The locations of the sections shown in Figures 6, 7, and 8 also are shown.

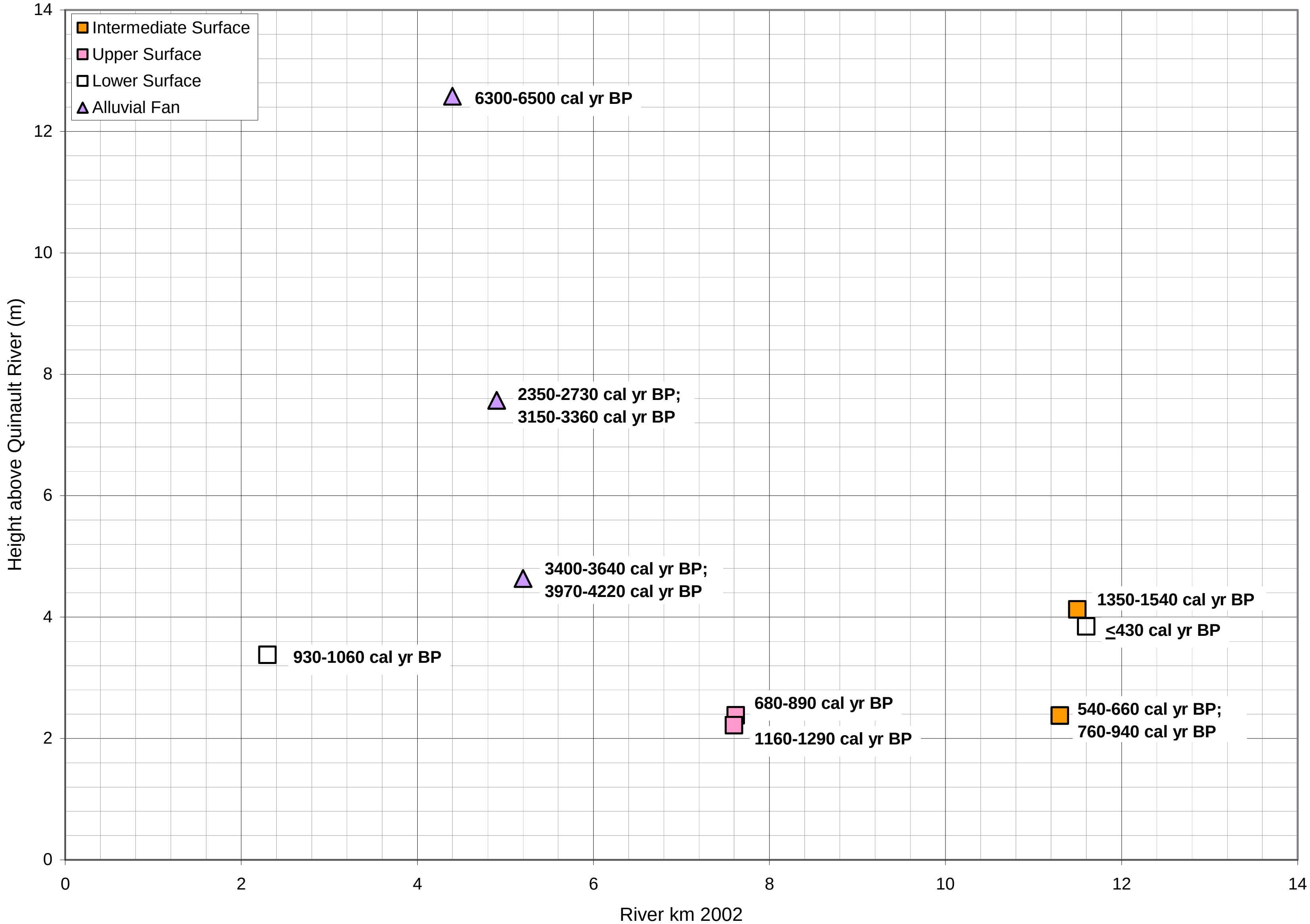

Figure 3. Radiocarbon ages plotted by location along the Middle Reach and height above the Quinault River (tables 2 and 3). Points with multiple dates indicate that more than one sample was collected and dated at the site.

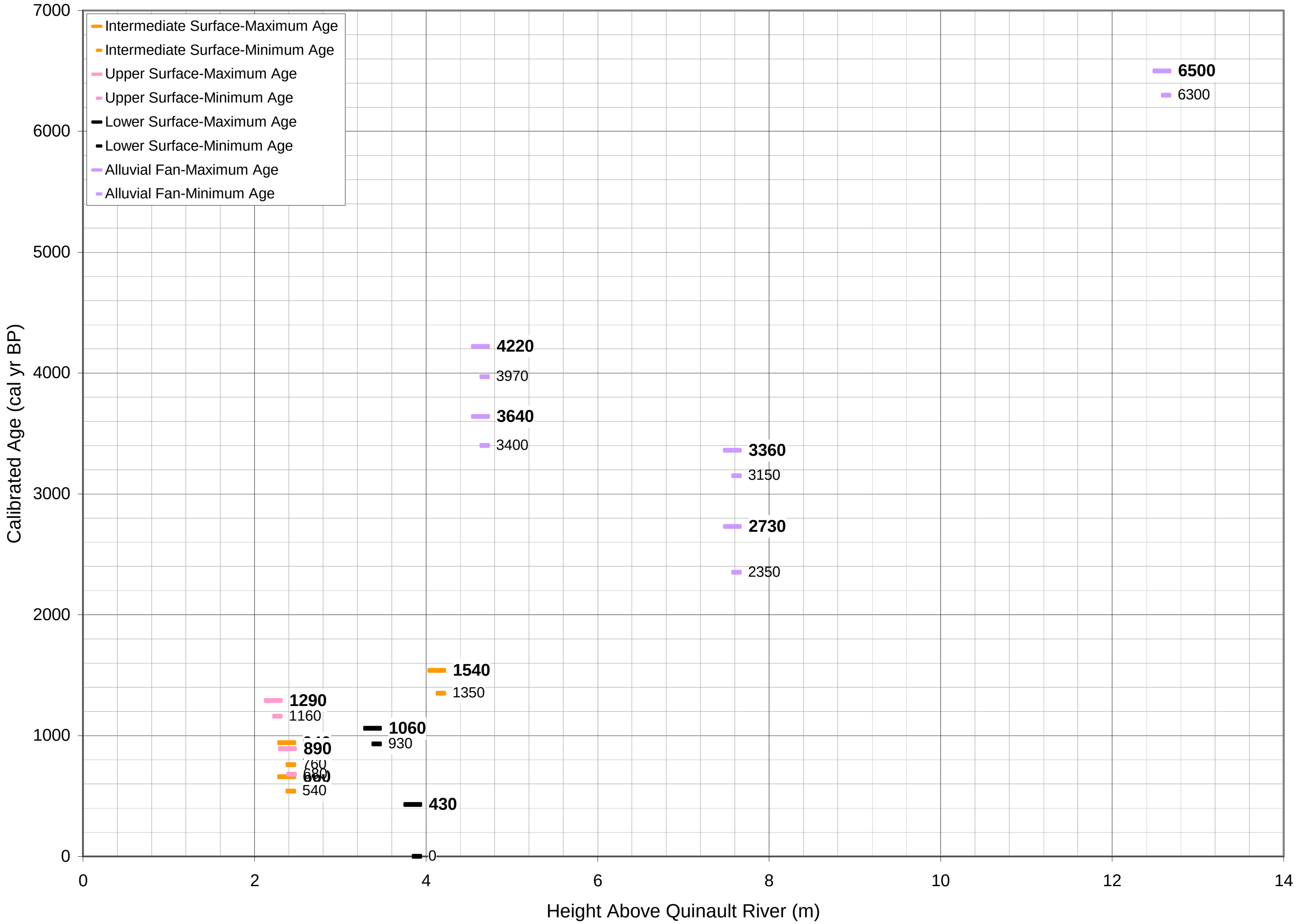

Figure 4. Radiocarbon ages plotted by the height of the samples above the Quinault River (tables 2 and 3).

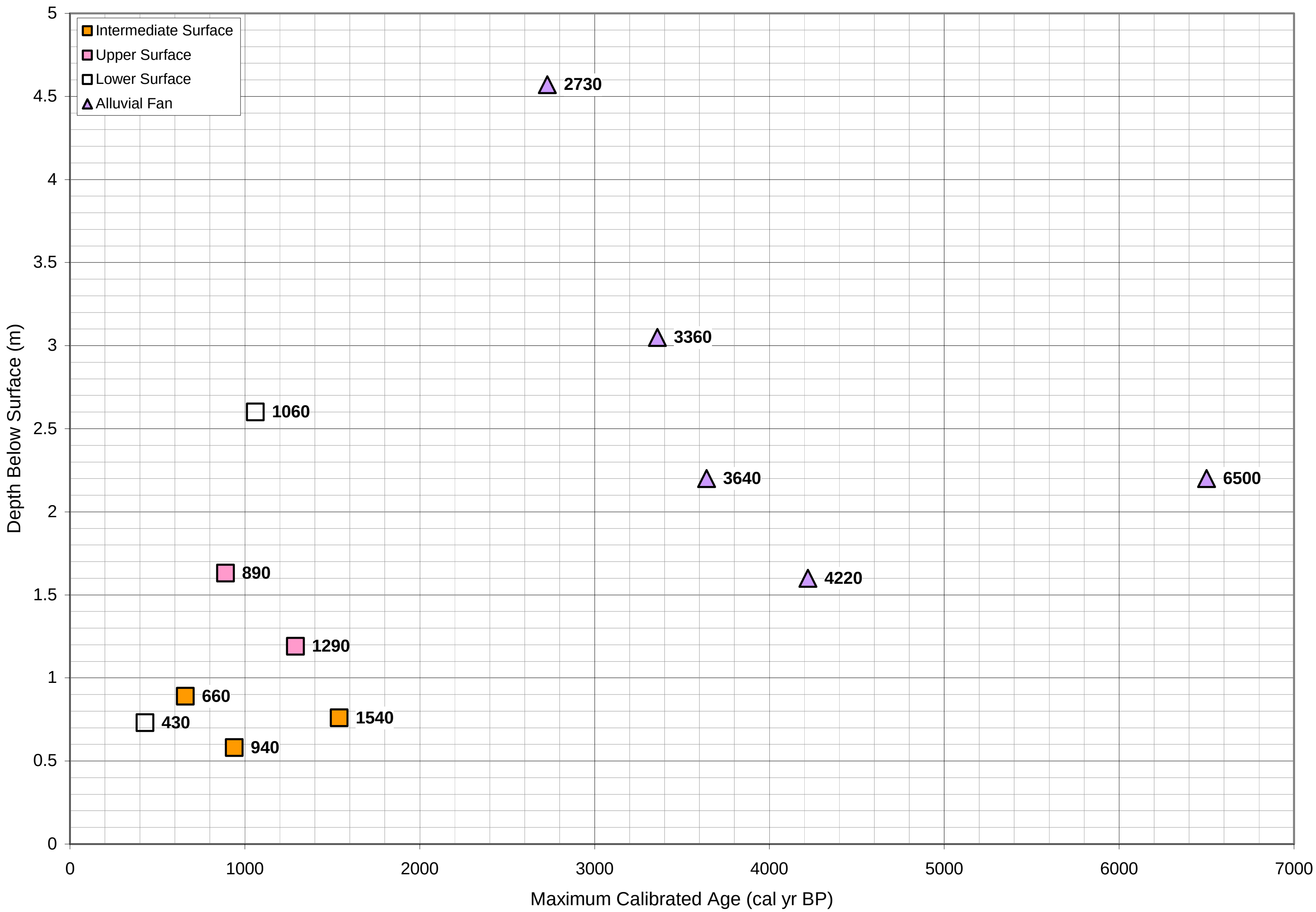

Figure 5. Maximum radiocarbon age plotted by sample depth below the ground surface (tables 2 and 3). For a given surface, samples stragraphically lower yielded younger dates, which is opposite to the expected trend (see text).

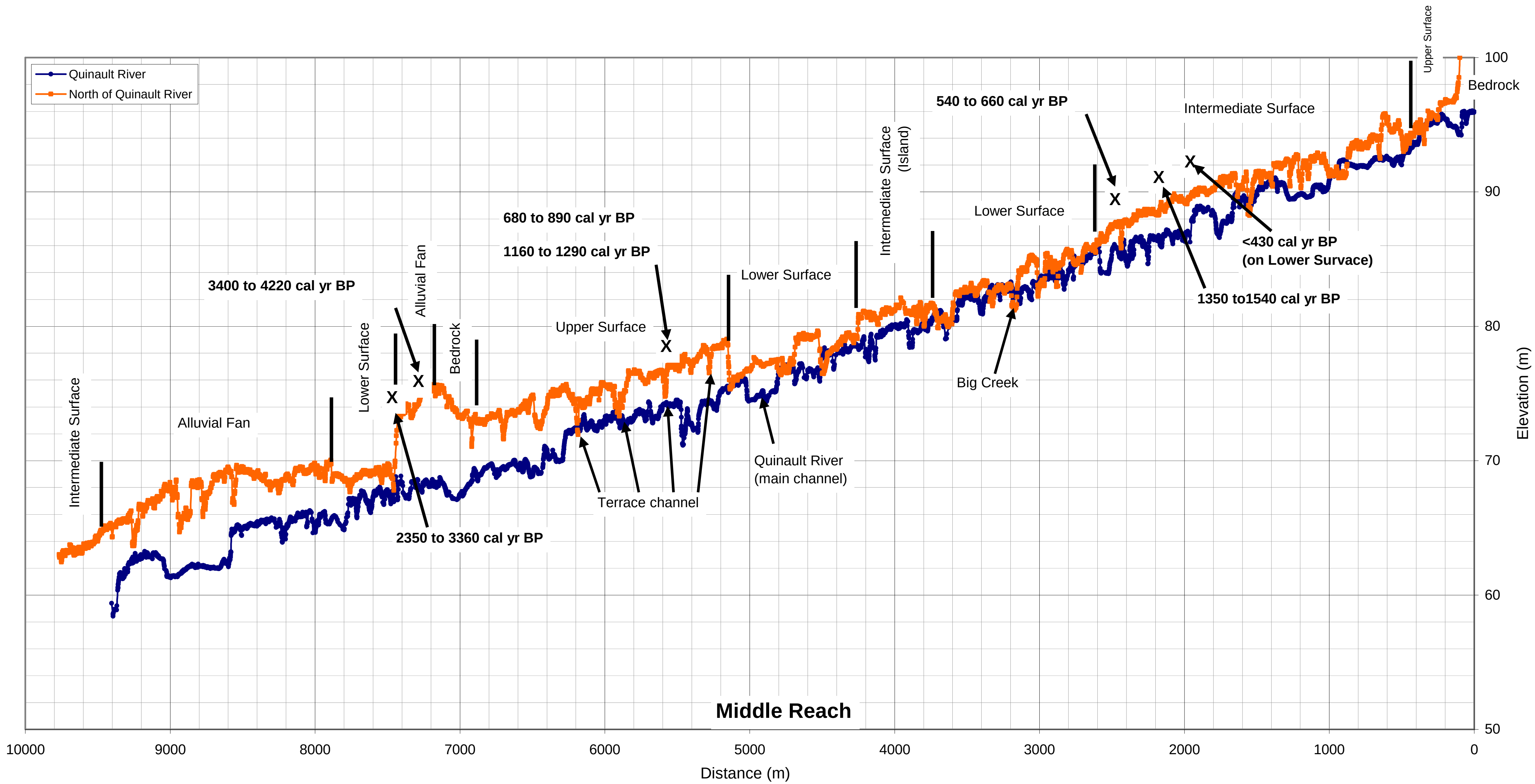

Figure 6. Longitudinal profiles along the Quinault River and surfaces along the north side of the valley as shown on Figure 2. Elevations and heights are from a TIN created from the 2002 Lidar data.

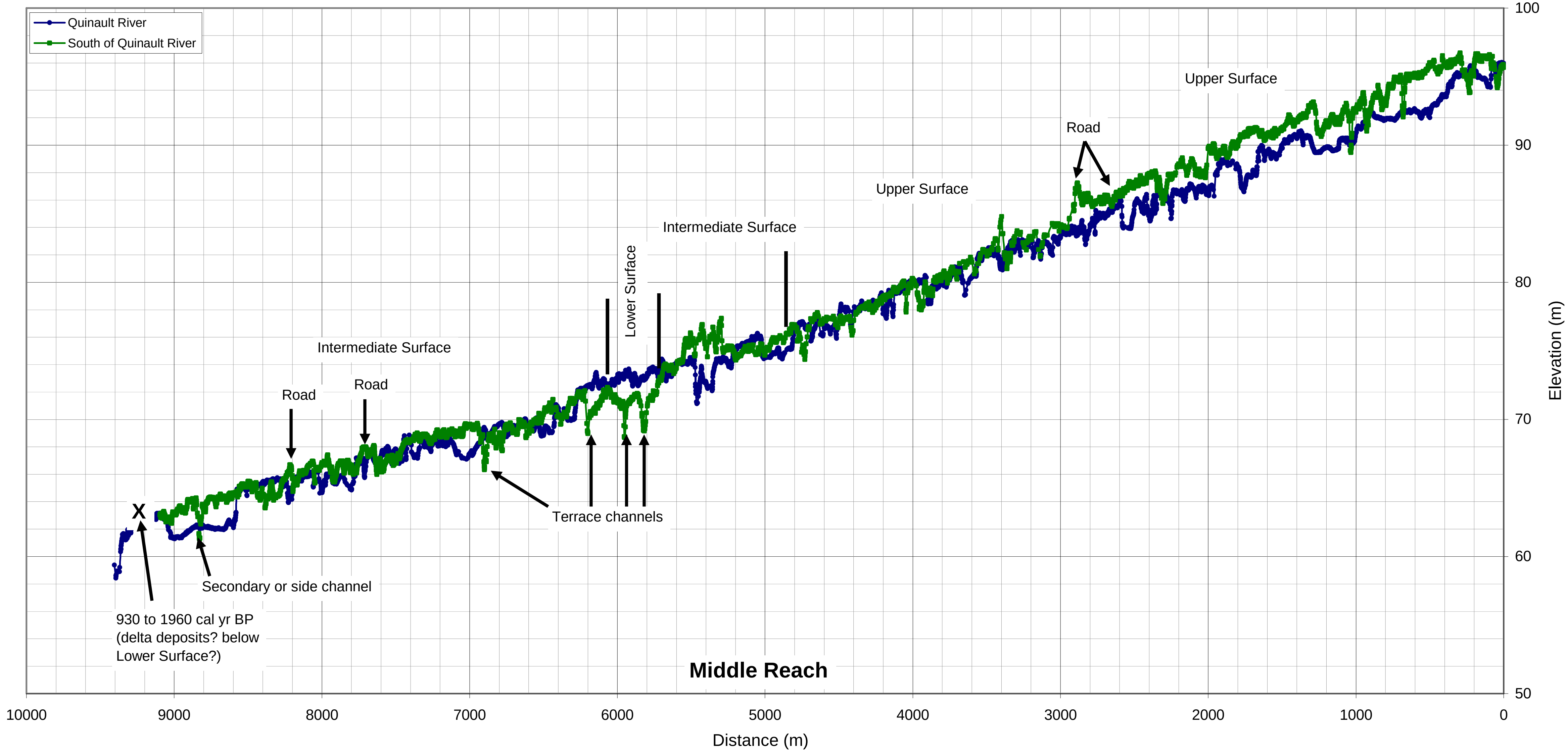

Figure 6. Longitudinal profiles along the Quinault River and surfaces along the south side of the valley as shown on Figure 2. Elevations and heights are from a TIN created from the 2002 Lidar data. The map unit along the south profile is on the Upper Surface upstream and the Intermediate Surface downstream. The height above the river for this surface varies across the valley (fig. 5) and along the valley.

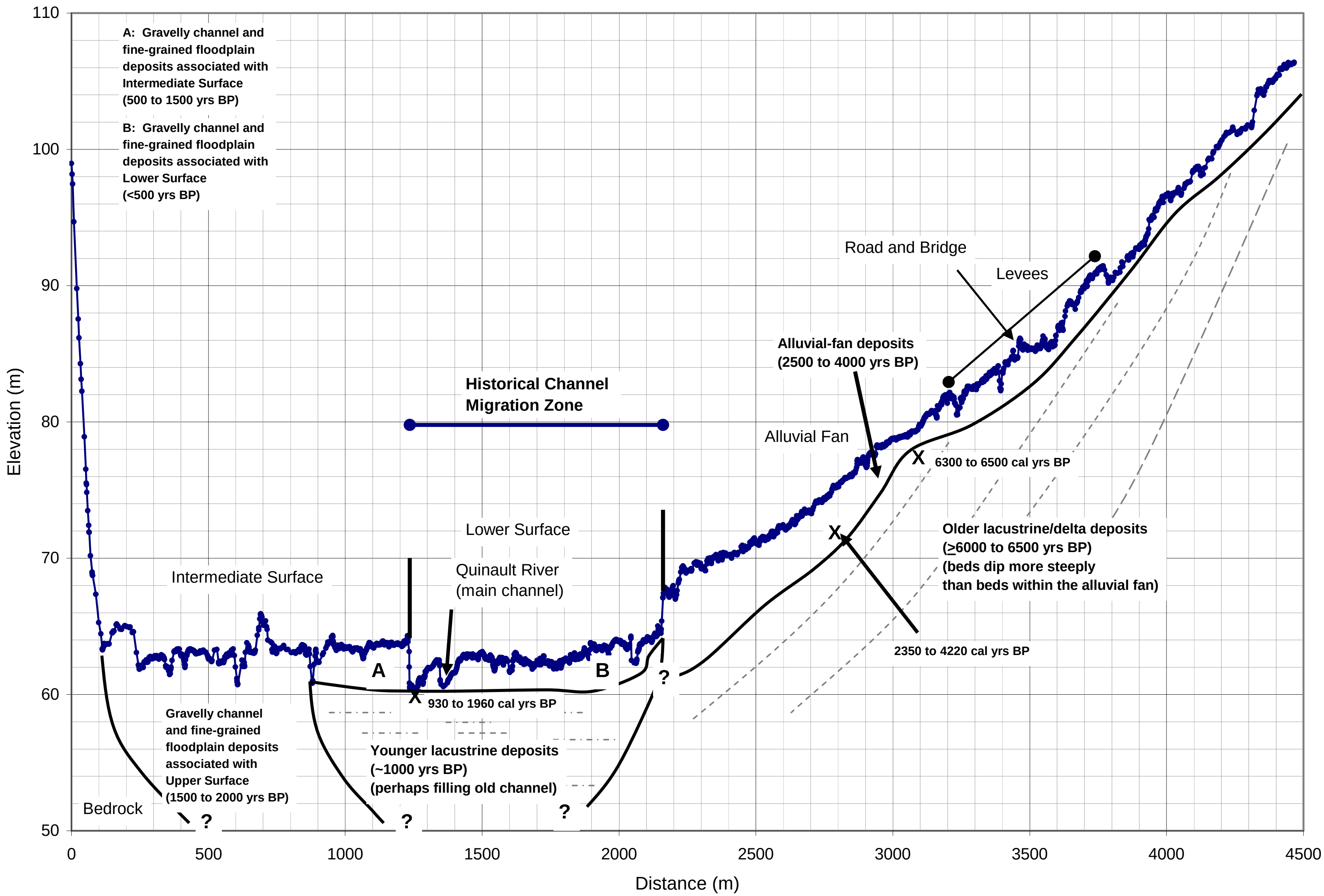

Figure 8. Generalized cross section in the Finley Creek area (fig. 2) showing the radiocarbon dates and an interpretation of the deposits dated and their stratigraphic relationship. Topography is from a TIN created from the 2002 Lidar data. See Appendix C (Geology) for a more detailed discussion.

Locations and Characteristics of Samples Collected for Radiocarbon Dating Along the Quinault River

Sample Number	Waypoint	Ref No	Location	Landform/deposit	Terrace	Type of Sample
92502-1-1		500	On north side of Quinault River east of Big Creek	Intermediate terrace (T2?); lowest floodplain deposit; exposed in channel	Terrace T2	Bulk sediment
92502-1-2		501	On north side of Quinault River east of Big Creek	Intermediate terrace (T2?); intermediate floodplain deposit	Terrace T2	Bulk sediment
92502-1-3		502	On north side of Quinault River east of Big Creek	Intermediate terrace (T2?); upper floodplain deposit	Terrace T2	Bulk sediment
92502-2-1	RT. 2, WP 2	2	On north side of Quinault River east of Big Creek; bank of highest terrace (T1?) in channel along contact with intermediate terrace (T2?)	Highest terrace (T1?); lower floodplain deposit	Terrace T1	Bulk sediment
92502-2-2	RT. 2, WP 3	3	On north side of Quinault River east of Big Creek; bank of highest terrace (T1?) in channel along contact with intermediate terrace (T2?)	Highest terrace (T1?); upper floodplain deposit	Terrace T1	Bulk sediment
92502-3-1	RT. 2, WP 21	21	On north side of Quinault River east of Finley Creek; bank of terrace (T2?) along intra-terrace channel	Intermediate terrace (T2?)	Terrace T2	Bulk sediment
92502-3-2	RT. 2, WP 22	22	On north side of Quinault River east of Finley Creek; bank along Quinault River?	Low terrace (T3)	Terrace T3	Bulk sediment
92602-1-1	RT. 3, WP 30	30				
92702-2-1	RT. 4, WP 72	72	On north side of Quinault River just east of Finley Creek; in bank along Quinault River	Terrace T3; gravelly alluvium	Terrace T3	Core from log
92702-4-1	RT. 4, WP 74	74	On north side of Quinault River east of Big Creek; bank of intra-terrace channel connecting Quinault River and Big Creek	Terrace T3?; terrace about 6 ft (1.8 m) above the Quinault River; lower floodplain deposit about 7 in (18 cm) thick	Terrace T3	Bulk sediment
92702-5-1	RT. 4, WP 89	89	On north side of Quinault River east of Big Creek; in bank of side channel of the Quinault River; just upstream of riprap along bank	Terrace T2?	Terrace T2	Bulk sediment

Locations and Characteristics of Samples Collected for Radiocarbon Dating Along the Quinault River

Sample Number	Waypoint	Ref No	Location	Landform/deposit	Terrace	Type of Sample
92802-1-1	RT. 5, WP 106	106	On north side of Quinault River along Survey Line #1 east of Big Creek	Terrace T2?	Terrace T2	Log
92802-3-1	RT. 5, WP 118	118	Bank in alluvial-fan deposits from Finley Creek; east of creek and north of Quinault River	Alluvial-fan deposits of Finley Creek		Bulk sediment
92802-3-2	RT. 5, WP 118	118	Bank in alluvial-fan deposits from Finley Creek; east of creek and north of Quinault River	Alluvial-fan deposits of Finley Creek		Bulk sediment
92802-5-1	RT. 6, WP 134	134	South side of Quinault River in bank along Harrington side channel	Terrace T2?	Terrace T2	Core from log
92902-1-1	RT. 6, WP 137	137	North side of Quinault River; bank along river at Finley Creek	Alluvial-fan deposits of Finley Creek		Bulk sediment
92902-1-2	RT. 6, WP 138	138	North side of Quinault River; bank along river at Finley Creek	Alluvial-fan deposits of Finley Creek		Bulk sediment
92902-1-3	RT. 6, WP 136	136	North side of Quinault River; in bank of incised drainage along Finley Creek; about 0.5 km downstream of bridge over Finley Creek	Lacustrine/delta deposits(?) of an ancestral Lake Quinault		Bulk sediment

Locations and Characteristics of Samples Collected for Radiocarbon Dating Along the Quinault River

Sample Number	Waypoint	Ref No	Location	Landform/deposit	Terrace	Type of Sample
93002-3-1	RT. 6, WP 190	190	South side of Quinault River; in bank at Pruce Boys Road	Terrace T1?	Terrace T1	Bulk sediment
81904-1		200	South side of Quinault River; in bank just downstream of Pruce Boys Road	Lacustrine deposits(?) of an ancestral Lake Quinault preserved beneath the Lower Surface		Bulk sediment

Abbreviation at end of sample number	Type of Charcoal Sample	Identifcation
ABR	*Abies* - Rounded	Fir, rounded edges (transported?)
AC	*Acer*	Maple, box elder
AL	*Alnus*	Alder
CO	Conifer	Cone-bearing
COR	Conifer - Rounded	Rounded edges (tranported?)
PI	*Picea*	Spruce
PO	*Populus*	Aspen, cottonwood
TS	*Tsuga*	Hemlock
UC	Unidentified charcoal	
UH	Unidentified hardwood	

Locations and Characteristics of Samples Collected for Radiocarbon Dating Along the Quinault River

Type of Sediment	Depth Below Surface (in)	Depth Below Surface (cm)	Height Above Gravelly Alluvium (in)	Height Above Gravelly Alluvium (cm)	Material > 2 mm	Sediment Color (Munsell; d, dry; m, moist)	Surface Vegetation
Silty clay	69	175	1	3	None	Mottled; Dark red (2.5YR 3/6 (d) and dark gray (gley chart 1, 4N)	
Sandy silt	35	89	35	89	None	Dark grayish brown (10YR 4/2 (d))	
Sandy silt	23	58	47	119	None	Very dark gray (10YR 3/1 (d))	
Silt	47	119	14	36		Mottled; Dark yellowish brown (10YR 4/4 (d)) and dark gray (10YR 4/1 (d))	Big-leaf maple with 4-ft diameters, alder, ferns, large stumps; lots of deadfall; ferns thick and tall
Sandy silt	30	76	31	79			
Silt	64	163	42	107		Dark gray (2.5Y 4/1 (d))	Fairly large alder, big-leaf maple (especially along channel)
Silty sand	47	119	4 to 6	10 to 15		Gray (2.5Y 5/1 (d))	Alder, Douglas fir, big-leaf maple
Cobbly gravel	52	131	NA	NA			Alder $\leq$1ft (30 cm) diameters
Silt	26 to 31	66 to 79	1	2.54		Mottled	
Silt	41 to 44	104 to 112	$\leq$3	$\leq$8			

Locations and Characteristics of Samples Collected for Radiocarbon Dating Along the Quinault River

Type of Sediment	Depth Below Surface (in)	Depth Below Surface (cm)	Height Above Gravelly Alluvium (in)	Height Above Gravelly Alluvium (cm)	Material > 2 mm	Sediment Color (Munsell; d, dry; m, moist)	Surface Vegetation
Gravelly alluvium	24	61	NA	NA	75% cobbles		Mostly unvegetated
Lower sand	84 to 89	213 to 226	NA	NA			
Upper sand	60 to 66	152 to 168	NA	NA			
Gravelly alluvium	65	165	NA	NA			
Silt (includes a bed of pebbles one-pebble thick)	180	457	NA	NA	60% small cobbles to pebbles		
Sand and silt beds	120	305	NA	NA			
Sand and silt beds			NA	NA			

Locations and Characteristics of Samples Collected for Radiocarbon Dating Along the Quinault River

Type of Sediment	Depth Below Surface (in)	Depth Below Surface (cm)	Height Above Gravelly Alluvium (in)	Height Above Gravelly Alluvium (cm)	Material > 2 mm	Sediment Color (Munsell; d, dry; m, moist)	Surface Vegetation
Silt	45 to 52	114 to 132	1	3		Mottled	
Silt	101	260	>16	>40			

Locations and Characteristics of Samples Collected for Radiocarbon Dating Along the Quinault River

Additional Notes	Charcoal Sample Number	Charcoal Sample Weight (g)
Underlying gravel is pebbly sand; sample taken at scour hole in intra-surface channel	92502-1-1UH	0.001
Underlying gravel is pebbly sand; sandier than sample 92502-1-3; sample taken at scour hole in intra-surface channel	92502-1-2AL 92502-1-2CO	0.004 0.003
Underlying gravel is pebbly sand; siltier than sample 92502-1-2; sample taken at scour hole in intra-surface channel	92502-1-3PI	0.058
Underlying gravel is cobbly; above gravel, 28 in (71 cm) of silt buried by 33 in (84 cm) of loose sandy silt; sample is 14 in (36 cm) below top of silt unit; lots of roots (difficult to dig)		
Underlying gravel is cobbly gravel; above gravel, 28 in (71 cm) of silt buried by 33 in (84 cm) of loose sandy silt; sample is in sandy silt unit 3 in (8 cm) above top of silt unit; lots of roots (difficult to dig)	92502-2-2CO 92502-2-2COR	0.007 0.003
Gravel is at a depth of about 67 in (170 cm); channel is about 72 in (183 cm) deep	92502-3-1CO	0.003
Underlying gravel is cobbly; gravel is at a depth of 51 in (130 cm); silty sand is loose	92502-3-2AL 92502-3-2CO	0.012 0.009
Log at depth of 17 in (43 cm) from top of gravel; dimensions of exposed portion of log: diameter is 20 in (51 cm); length is 198 in (503 cm); partial core recovered; could not identify species		
Underlying is cobbly; sample from silt unit just above gravel; about 2 in (5 cm) above the sample, an upper unit of cross-bedded sand 24 in (61 cm) thick is present; bank appears to have eroded in the winter of 2001-2002	92702-4-1PO 92702-4-1UC	0.005 0.004
Underlying gravel is cobbly; sample from lowest floodplain deposit; sandy unit and sand and silt unit are above the silt unit where sample was collected; lots of roots	92702-5-1AC	0.001

Locations and Characteristics of Samples Collected for Radiocarbon Dating Along the Quinault River

Additional Notes	Charcoal Sample Number	Charcoal Sample Weight (g)
Log (probably alder 10 yr old) is in cobbly gravel; log is 62 in (157 cm) above low water elevation; top of surface is 86 in (218 cm) above low-water elevation; about 5 in (13 cm) of sand and silt are at top of surface where log was collected; sand/sit bed to right is buried by cobbly gravel about 1 ft (30 cm) thick (flood deposit)		
Sand bed within alluvial-fan deposits that include gravel beds; top of alluvial-fan surface is 146 in (371 cm; 3.7 m)? above water level	92802-3-1COR 92802-3-1CO 92802-3-1TSR	0.011 0.003 0.009
Sand bed within alluvial-fan deposits that include gravel beds; top of alluvial-fan surface is 146 in (371 cm; 3.7 m)? above water level	92802-3-2CO 92802-3-2COR 92802-3-2ABR	0.016 0.027 0.023
Log located 15 cm below top of gravelly alluvium; diameter of log is 21 cm		
Silt unit is below alluvial-fan gravelly alluvium (60% SR-R small cobbles to pebbles); exposure is mostly silt with beds and lenses of gravel; depth estimated (could not measure); silt bed sampled is 30 in (76 cm) thick; bank is about 20 ft (6.1 m) high		
Sample is from a unit of sand and silt beds (thin) within the alluvial-fan deposit; sample about 60 in (152 cm) above Sample 92902-1-1; one piece of charcoal was noted and collected; bank is about 20 ft (6.1 m) high	92902-1-2AL 92902-1-2CO 92902--1-2COR 92902-1-2TS	0.006 0.013 0.003 0.007
Sample is from a unit that includes lenses of both sand and silt; approximately the same height as a gravel bed or lens that pinches out upstream of sample site	92902-1-3CO 92902-1-3COR	0.008 0.005

Locations and Characteristics of Samples Collected for Radiocarbon Dating Along the Quinault River

Additional Notes	**Charcoal Sample Number**	**Charcoal Sample Weight (g)**
Lowest floodplain unit; upper 18 in (46 cm) of gravel is iron stained; upper 4 ft (1.2 m) of gravelly alluvium is weakly cemented above a more strongly cemented bed; bank is 10.5 ft (3.2 m) high above water in the low-water channel; terrace is probably correlative with Terrace T1; height is lower than it is upstream, but terraces may be converging toward Lake Quinault; bank is at the outside of a meander bend and has	81904-1-1CO	0.005

EXAMINATION OF BULK SEDIMENT FOR RADIOCARBON DATABLE MATERIAL FROM ALONG THE QUINALT RIVER IN THE WESTERN OLYMPIC PENINSULA, WASHINGTON

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INTRODUCTION

A total of 15 bulk sediment samples from the Quinault River drainage basin in the western Olympic Peninsula, Washington, were floated to recover organic fragments suitable for radiocarbon analysis. Samples were recovered from floodplain deposits on terraces inset into a glacial moraine that dams Lake Quinault, as well as from sand and silt beds within alluvial fan deposits from Finley Creek, a major tributary in this section of the Quinault River. Botanic components and detrital charcoal were identified, and potentially radiocarbon datable material was separated.

METHODS

The bulk samples were floated using a modification of the procedures outlined by Matthews (1979). Each sample was added to approximately 3 gallons of water. The sample was stirred until a strong vortex formed, which was allowed to slow before pouring the light fraction through a 150 micron mesh sieve. Additional water was added and the process repeated until all visible macrofloral material was removed from the sample (a minimum of 5 times). The material which remained in the bottom (heavy fraction) was poured through a 0.5 mm mesh screen. The floated portions were allowed to dry.

The light fractions were weighed, then passed through a series of graduated screens (US Standard Sieves with 4 mm, 2 mm, 1 mm, 0.5 mm and 0.25 mm openings to separate charcoal debris and to initially sort the remains. The contents of each screen were then examined. Charcoal pieces larger than 0.5 to 2 mm in diameter were broken to expose a fresh cross-section and examined under a binocular microscope at a magnification of 70x. Some pieces were further examined at 400-800x using a Nikon Optiphot 66 microscope. The remaining light fraction in the 4 mm, 2 mm, 1 mm, 0.5 mm, and 0.25 mm sieves was scanned under a binocular stereo microscope at a magnification of 10x, with some identifications requiring magnifications of up to 70x. The material which passed through the 0.25 mm screen was not examined. The coarse or heavy fractions also were screened and examined for the presence of botanic remains. Remains from both the light and heavy fractions were recorded as charred and/or uncharred, whole and/or fragments. Individual detrital charcoal/wood samples also were broken to expose a fresh cross-section and examined under a binocular microscope at a magnification of 70x.

Macrofloral remains, including charcoal, were identified using manuals (Core *et al.* 1976; Martin and Barkley 1973; Panshin and Zeeuw 1980; Petrides and Petrides 1992) and by comparison with modern and archaeological references. The term "seed" is used to represent seeds, achenes, caryopses, and other disseminules. Because charcoal and possibly other botanic remains were to be sent for radiocarbon analysis, clean laboratory conditions were used during flotation and identification to avoid contamination. All instruments were washed between samples, and samples were protected from contact with modern charcoal.

DISCUSSION

Bulk sediment samples were recovered from the Quinault River drainage basin in the western Olympic Peninsula, Washington. The lower river terraces are vegetated with a variety of riparian species, primarily alder (*Alnus*) and some cottonwood (*Populus*). The higher terraces contain rain forest species such as bigleaf maple (*Acer macrophyllum*), sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), Douglas-fir (*Pseudotsuga menziesii*), and sword fern (*Polystichum*).

Twelve samples were collected from natural exposures on stream terraces adjacent to the Quinault River between RK56 and R. 84. This section of the Quinault River drains the western Olympic mountains and flows into Lake Quinault, which is dammed by a glacial moraine. The samples are from floodplain deposits on terraces inset into the moraine.

Sample 92502-1-1 was taken from silty clay above gravelly sand at a depth of 5' 9" below the surface (Table 1). This sample contained very small fragments of unidentified hardwood charcoal weighing 0.001 g (Table 2, Table 3). The minimum requirement of charcoal for standard AMS radiocarbon analysis reported by Beta Analytic, Inc. is 5 mg or 0.005 g; however, Beta now offers an AMS-MS dating technique for very small sample sizes. It now is possible to date charcoal weighing 1 mg or 0.001 g. Pieces of conifer charcoal, including a piece exhibiting rounded edges, weighed less than 0.001 g. Recovery of insect eggs, insect chitin fragments, and several uncharred remains from modern plants indicates some subsurface disturbance and introduction of modern material into this area. A few sclerotia also were present.

Sclerotia are commonly called "carbon balls". They are small, black, solid or hollow spheres that can be smooth or lightly sculpted. These forms range from 0.5 to 4 mm in size. Sclerotia are associated with mycorrhizae fungi, such as *Cenococcum graniforme*, that have a mutualistic relationship with tree roots. Sclerotia are the resting structures of the fungus, identified by Dr. Kristiina Vogt, Professor of Ecology in the School of Forestry and Environmental Studies at Yale University. Many trees are noted to depend heavily on mycorrhizae and may not be successful without them. "The mycelial strands of these fungi grow into the roots and take some of the sugary compounds produced by the tree during photosyntheses. However, mycorrhizal fungi benefit the tree because they take in minerals from the soil, which are then used by the tree" (Kricher and Morrison 1988:285). Sclerotia appear to be ubiquitous and are found with coniferous and deciduous trees including *Abies* (fir), *Juniperus communis* (common juniper), *Larix* (larch), *Picea* (spruce), *Pinus* (pine), *Pseudotsuga* (Douglas fir), *Acer pseudoplatanus* (sycamore maple), *Alnus* (alder), *Betula* (birch), *Carpinus caroliniana* (American hornbeam), *Carya* (hickory), *Castanea dentata* (American chestnut), *Corylus* (hazelnut), *Crataegus monogyna* (hawthorn), *Fagus* (beech), *Populus* (poplar, cottonwood, aspen), *Quercus* (oak), *Rhamnus fragula* (alder bush), *Salix* (willow), *Sorbus* (chokecherry), and *Tilia* (linden) (McWeeney 1989:229-130; Trappe 1962).

Sample 92502-1-2 from sandy silt at a depth of 2' 11" below the surface yielded one piece of *Alnus* charcoal weighing 0.004 g and conifer charcoal weighing 0.003 g that can be submitted for radiocarbon analysis. The sample also contained four charred *Picea* needle fragments weighing less than 0.001 g, a piece of *Pseudotsuga menziesii* charcoal weighing less than 0.001 g, unidentified charcoal fragments, uncharred wood, uncharred remains from modern plants, a moderate amount of sclerotia, and a few insect chitin fragments.

One piece of *Picea* charcoal weighing 0.058 g was present in sample 92502-1-3 from a depth of 1' 1" below the surface and can be submitted for AMS radiocarbon analysis. Several uncharred seeds and rootlets from modern plants, as well as several insect chitin fragments, reflect bioturbation and the closer proximity of this sample to the modern surface.

Sample 92502-2-1 was recovered from the T1 terrace upstream of Big Creek at a depth of 3' 11" below the surface. This sample contained very small fragments of conifer charcoal and unidentified hardwood charcoal with rounded edges weighing less than 0.001 g. One charred *Picea* needle fragment and two uncharred needle fragments, an uncharred *Pseudotsuga* needle fragment, and a few uncharred *Thuja* leaf fragments represent local spruce, Douglas-fir, and western red cedar trees. In addition, the sample contained an uncharred *Scirpus* seed, numerous uncharred rootlets, a few sclerotia, uncharred wood, insect eggs, insect chitin fragments, and a small amount of rock/gravel.

Sample 92502-2-2 was taken from sandy silt on the T1 terrace upstream of Big Creek at a depth of 2' 9". Small fragments of conifer charcoal weighing 0.007 g were present and can be submitted for AMS radiocarbon analysis. Pieces of conifer charcoal with rounded edges weighing 0.003 g, pieces of *Pseudotsuga* charcoal weighing less than 0.001 g, unidentified hardwood charcoal weighing less than 0.001 g, unidentified charcoal and unidentified wood also were present. One piece of charred, vitrified tissue might represent charcoal or other plant tissue too vitrified for identification. Vitrified material has a shiny, glassy appearance due to fusion by heat. Uncharred remains from modern plants, sclerotia, insect chitin fragments, and a small amount of rock/gravel and sand complete the record.

Sample 92502-3-1 from a depth 5' 4" contained several small fragments of conifer charcoal weighing 0.003 g, as well as two pieces of hardwood charcoal too small for further identification weighing 0.001 g, one partially charred piece of conifer charcoal weighing less than 0.001 g, *Pseudotsuga* charcoal weighing less than 0.001 g, and unidentified charcoal. Plant remains noted in this sample include a charred conifer needle fragment weighing 0.001 g, one charred *Rubus* seed and several uncharred *Rubus* seeds, an uncharred *Chenopodium* seed, several uncharred *Sambucus* seeds, and numerous uncharred rootlets. The sample also contained a few sclerotia, a piece of charred unidentified organic tissue, and a few insect chitin fragments.

Several charcoal types were present in sample 92502-3-2 from a depth of 3' 11", including *Alnus* charcoal weighing 0.012 g, *Picea* charcoal weighing 0.003 g, *Pseudotsuga* charcoal weighing 0.017 g, conifer charcoal weighing 0.009 g, unidentified hardwood charcoal weighing less than 0.001 g, and unidentified charcoal. The sample also contained charred *Picea* needle fragments weighing 0.004 g, charred conifer bark fragments weighing 0.030 g, charred unidentified bark fragments weighing 0.006 g, charred unidentified organic tissue, a piece of charred vitrified tissue, a charred *Sambucus* seed, several uncharred *Sambucus* and *Rubus* seeds and seed fragments, numerous uncharred rootlets, a moderate amount of sclerotia, and a few pieces of uncharred wood. Non-floral remains include several insect chitin fragments and sand.

Sample 92702-4-1 was recovered from silt at a depth of 2' 2" to 2' 7". This sample yielded a piece of *Populus* charcoal weighing 0.005 g that can be submitted for AMS radiocarbon analysis. The sample also contained unidentified charcoal and wood, a few charred *Picea* needle fragments, a few uncharred seeds and numerous rootlets from modern plants, a few sclerotia, several insect chitin fragments, and a small amount of sand.

Sample 97502-5-1 was taken from a depth of 3' 5" to 3' 8" below the surface. This sample contained one piece of *Acer* charcoal weighing 0.001 g, three small fragments of conifer charcoal weighing less than 0.001 g, a piece of *Pseudotsuga* charcoal weighing less than 0.001 g, and unidentified wood. A few charred *Picea* needle fragments, uncharred seeds and rootlets from modern plants, uncharred moss fragments, a few sclerotia, a few insect chitin fragments, and a small amount of rock/gravel and sand also were present.

Sample 92802-3-1 was collected from the lower sand and diatomite layer just below the sand at a depth of 7' to 7' 5" below the surface. This sample contained a partially charred piece of *Tsuga* charcoal with rounded edges weighing 0.009 g, several small fragments of conifer charcoal weighing 0.003 g, pieces of conifer charcoal with rounded edges weighing 0.011 g, unidentified charcoal, and a charred unidentified bark fragment weighing 0.008 g. Two small *Picea sitchensis* needle fragments weighing less than 0.001 g represent local sitka spruce trees. The sample also yielded uncharred unidentified plant fibers, a few uncharred rootlets from modern plants, a moderate amount of rock/gravel, and an abundance of sand.

Sample 92802-3-2 from the upper sand at a depth of 5' to 5' 6" contained pieces of conifer charcoal weighing 0.016 g, conifer charcoal with rounded edges weighing 0.027 g, pieces of *Alnus* charcoal with rounded edges weighing 0.023 g, unidentified charcoal, and charred bark fragments weighing 0.010 g. A few uncharred rootlets, a few sclerotia, two insect chitin fragments, and a small amount of sand complete the record.

Sample 93002-3-1 at depth of 3' 9" to 4' 4" contained very small fragments of conifer charcoal weighing less than 0.001 g. A moderate amount of uncharred bark fragments were present in this sample, including bark exhibiting an orange coating. The sample also contained numerous uncharred rootlets, a few sclerotia, a few insect chitin fragments, and a moderate amount of rock/gravel and sand.

Samples 92902-1-1, 92902-1-2, and 92902-1-3 were recovered from sand and silt beds within alluvial fan deposits from Finley Creek, a major tributary in this section of the Quinault River. Sample 92902-1-1 represents a silt bed below the alluvial fan gravel at a depth of 15'. Pieces of conifer charcoal weighing 0.006 g were present and can be submitted for AMS radiocarbon analysis. Pieces of conifer charcoal with rounded edges and a yellowish-orange coating weighing 0.003 g, unidentified charcoal, one charred conifer needle fragment weighing less than 0.001 g, a few uncharred *Picea* and *Tsuga* needles, numerous uncharred rootlets, a few insect chitin fragments, and a small amount of sand also were present.

Sample 92902-1-2 was collected from sand/silt in the alluvial fan deposit at a depth of 10' below the surface. This sample contained a variety of charcoal types including a piece of *Alnus* weighing 0.006 g, small fragments of conifer weighing 0.013 g, conifer charcoal with rounded edges weighing 0.003 g, a piece of *Tsuga* charcoal weighing 0.007 g, unidentified charcoal, and charred bark weighing 0.057 g. One charred insect fecal pellet was present and might indicate that some of the burned wood contained insects. Recovery of several insect chitin fragments and a few rodent fecal pellets indicates some subsurface disturbance from insect and rodent activity. The sample also contained uncharred unidentified plant fibers, a moderate amount of uncharred rootlets, a few sclerotia, and a small amount of sand.

Sample 92902-1-3 was taken from sand/silt beds about one-quarter mile downstream of the Finley Creek Bridge. This sample contained several small fragments of conifer charcoal weighing 0.008 g than can be submitted for AMS radiocarbon analysis, as well as conifer charcoal with rounded edges and a yellowish-orange coating weighing 0.005 g. Several fragments of what appear to be coal also were present. In addition, the sample yielded a few uncharred rootlets, a few sclerotia, and three insect chitin fragments.

SUMMARY AND CONCLUSIONS

Flotation of bulk sediment samples from along the Quinault River in western Washington resulted in recovery of charcoal and other charred botanic remains that can be sent for radiocarbon analysis. The identified charcoal types represent trees found in the local vegetation community. Several fragments of charcoal exhibiting rounded edges suggest transport of charcoal from farther away.

Attachment 2, Appendix (Radiocarbon Dates)

TABLE 1

PROVENIENCE DATA FOR SAMPLES FROM THE QUINAULT RIVER GEOMORPHIC STUDY

Sample No.	Depth below surface	Provenience/ Description	Analysis
92502-1-1	5' 9"	Bulk sediment; Silty clay above gravelly sand	Float/Charcoal ID for C14 Analysis
92502-1-2	2' 11"	Bulk sediment; Sandy silt, T2 upstream of Big Creek	Float/Charcoal ID for C14 Analysis
92502-1-3	1' 11"	Bulk sediment; Sandy silt, T2 upstream of Big Creek	Float/Charcoal ID for C14 Analysis
92502-2-1	3' 11"	Bulk sediment; T1 upstream of Big Creek	Float/Charcoal ID for C14 Analysis
92502-2-2	2' 9"	Bulk sediment; Sandy silt, T2 upstream of Big Creek	Float/Charcoal ID for C14 Analysis
92502-3-1	5' 4"	Bulk sediment; Above gravel beneath Terrace T2 upstream of Finley Creek	Float/Charcoal ID for C14 Analysis
92502-3-2	3' 11"	Bulk sediment; Just above gr. Terrace T3	Float/Charcoal ID for C14 Analysis
92702-4-1	2' 2" - 2' 7"	Bulk sediment; Silt	Float/Charcoal ID for C14 Analysis
92702-5-1	3' 5" - 3' 8"	Bulk sediment; Side channel of Quinault River of Big Creek, T2?	Float/Charcoal ID for C14 Analysis
92802-3-1	7' - 7' 5"	Bulk sediment; Lower sand and diatomite layer just below sand	Float/Charcoal ID for C14 Analysis
92802-3-2	5' - 5' 6"	Bulk sediment; Upper sand	Float/Charcoal ID for C14 Analysis
93002-3-1	3' 9" - 4' 4"	Bulk sediment; Silt above gravel, Pruce Boys Rd., T1?	Float/Charcoal ID for C14 Analysis
92902-1-1	15'	Bulk sediment; Silt bed below alluvial fan gravel at Finley Creek	Float/Charcoal ID for C14 Analysis
92902-1-2	10'	Bulk sediment; Sand/silt in alluvial fan deposit	Float/Charcoal ID for C14 Analysis
92902-1-3		Bulk sediment; Sand/silt beds about 1/4 mile downstream of Finley Creek Bridge	Float/Charcoal ID for C14 Analysis

TABLE 2 (Continued)

TABLE 2
MACROFLORAL REMAINS FROM THE QUINALT RIVER GEOMORPHIC STUDY

Sample No.	Identification	Part	Charred W	Charred F	Uncharred W	Uncharred F	Weights/ Comments
92502-1-1	Liters Floated						2.00 L
5' 9"	Light Fraction Weight						11.40 g
	FLORAL REMAINS:						
	Alnus ≥ 1mm	Seed			90	12	
	Alnus < 1mm	Seed			X	X	Moderate
	Calandrinia	Seed				9	
	Conifer	Male cone			2		
	Picea sitchensis	Needle				X	Few
	Rubus	Seed			1		
	Thuja plicata	Leaf				X	Few
	Unidentified	Seed			2	1	
	Rootlets					X	Numerous
	Sclerotia				X	X	Few
	CHARCOAL/WOOD:						
	Unidentified hardwood	Charcoal		6			0.001 g
	Conifer - rounded	Charcoal		1			< 0.001 g
	Conifer	Charcoal		4			< 0.001 g
	NON-FLORAL REMAINS:						
	Insect	Egg				40	
	Insect	Chitin				27	
	Rock/Gravel					X	Moderate
92502-1-2	Liters Floated						2.40 L
2' 11"	Light Fraction Weight						6.32 g
	FLORAL REMAINS:						
	Picea	Needle		4			< 0.001 g
	Calandrinia	Seed			1	1	
	Rubus	Seed				38	
	Sambucus	Seed			2	15	
	Rootlets					X	Moderate
	Sclerotia				X	X	Moderate
92502-1-2	CHARCOAL/WOOD:						
2' 11"	*Alnus*	Charcoal		1			0.004 g

TABLE 2 (Continued)

Sample No.	Identification	Part	Charred W	Charred F	Uncharred W	Uncharred F	Weights/ Comments
	Conifer	Charcoal		12			0.003 g
	Pseudotsuga menziesii	Charcoal		1			< 0.001 g
	Unidentified $\geq$ 1mm	Charcoal		X			0.001 g
	Unidentified	Wood				X	0.07 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				15	
	Rock/Gravel and Sand					X	Few
92502-1-3	Liters Floated						2.60 L
1' 11"	Light Fraction Weight						2.63 g
	FLORAL REMAINS:						
	Calandrinia	Seed			8	64	
	Caryophyllaceae	Seed			3	5	
	Rubus	Seed				2	
	Sambucus	Seed			1	1	
	Rootlets					X	Numerous
	Sclerotia				X	X	Few
	CHARCOAL/WOOD:						
	Picea	Charcoal		1			0.058 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				65	
	Sand					X	Few
92502-2-1	Liters Floated						2.10 L
3' 11"	Light Fraction Weight						18.94 g
	FLORAL REMAINS:						
	Picea	Needle		1		2	
	Pseudotsuga menziesii	Needle				1	
	Scirpus	Seed			1		
	Thuja plicata	Leaf				X	Few
	Rootlets					X	Numerous
	Sclerotia				X	X	Few
92502-2-1	CHARCOAL/WOOD:						
3' 11"	Conifer	Charcoal		1			< 0.001 g
	Unidentified hardwood - rounded	Charcoal		1			< 0.01 g

TABLE 2 (Continued)

Sample No.	Identification	Part	Charred W	Charred F	Uncharred W	Uncharred F	Weights/ Comments
	Unidentified ≥ 1mm	Wood				X	0.017 g
	NON-FLORAL REMAINS:						
	Insect	Egg			5	15	
	Insect	Chitin				33	
	Rock/Gravel					X	Few
92502-2-2	Liters Floated						3.10 L
2' 9"	Light Fraction Weight						12.03 g
	FLORAL REMAINS:						
	Vitrified tissue			1			0.002 g
	Conifer	Needle				1	
	Picea sitchensis	Needle				1	
	Picea	Seed			2		
	Sambucus	Seed			2	1	
	Rootlets					X	Numerous
	Sclerotia				X	X	Few
	CHARCOAL/WOOD:						
	Conifer	Charcoal		30			0.007 g
	Conifer - rounded	Charcoal		5			0.003 g
	Pseudotsuga menziesii	Charcoal		3			< 0.001 g
	Unidentified hardwood	Charcoal		2			< 0.001 g
	Unidentified ≥ 0.5 mm	Charcoal		X			0.004 g
	Unidentified ≥ 1mm	Wood				X	0.022 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				26	
	Rock/Gravel					X	Few
	Sand					X	Scant
92502-3-1	Liters Floated						2.20 L
5' 4"	Light Fraction Weight						5.17 g
	FLORAL REMAINS:						
	Conifer	Needle		1			0.001 g
	Rubus	Seed	1		10	11	
	Unidentified organic tissue		1				0.001 g
	Chenopodium	Seed			1		

TABLE 2 (Continued)

Sample No.	Identification	Part	Charred W	Charred F	Uncharred W	Uncharred F	Weights/ Comments
	Sambucus	Seed			10	76	
	Rootlets					X	Numerous
	Sclerotia				X	X	Few
	CHARCOAL/WOOD:						
	Conifer	Charcoal		15			0.003 g
	Conifer	Charcoal		1			< 0.001 g
	Pseudotsuga menziesii	Charcoal		2			< 0.001 g
	Unidentified hardwood	Charcoal		2			0.001 g
	Unidentified ≥ 0.5 mm	Charcoal		X			0.004 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				3	
92502-3-2	Liters Floated						2.60 L
3' 11"	Light Fraction Weight						12.73 g
	FLORAL REMAINS:						
	Picea	Needle		16			0.004 g
	Unidentified organic tissue			7			0.004 g
	Vitrified tissue			1			< 0.001 g
	Rubus	Seed			1	12	
	Sambucus	Seed	1		3	20	
	Rootlets					X	Numerous
	Sclerotia				X	X	Moderate
92502-3-2	CHARCOAL/WOOD:						
3' 11"	*Alnus*	Charcoal		11			0.012 g
	Conifer	Charcoal		12			0.009 g
	Picea	Charcoal		3			
	Pseudotsuga menziesii	Charcoal		7			
	Unidentified hardwood	Charcoal		3			
	Unidentified ≥ 1mm	Charcoal		X			
	Conifer bark			7			
	Unidentified bark			5			
	Unidentified	Wood				X	Few
	NON-FLORAL REMAINS:						
	Insect	Chitin				32	
	Sand					X	Few

TABLE 2 (Continued)

Sample No.	Identification	Part	Charred W	Charred F	Uncharred W	Uncharred F	Weights/ Comments
92702-4-1	Liters Floated						2.00 L
2' 2" - 2' 7"	Light Fraction Weight						6.82 g
	FLORAL REMAINS:						
	Picea	Needle		x			Few
	Calandrinia	Seed			1		
	Rubus	Seed				2	
	Sambucus	Seed			1		
	Rootlets					X	Numerous
	Sclerotia					X	Few
	CHARCOAL/WOOD:						
	Populus	Charcoal		1			0.005 g
	Unidentified ≥ 0.5 mm	Charcoal		X			0.004 g
	Unidentified	Wood					0.041 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				39	
	Sand					X	Few
92702-5-1	Liters Floated						1.10 L
3' 5" - 3' 8"	Light Fraction Weight						3.77 g
	FLORAL REMAINS:						
	Picea	Needle		X			Few
	Calandrinia	Seed				21	
	Rubus	Seed			1	7	
	Moss				X		Moderate
	Rootlets					X	Numerous
	Sclerotia					X	Few
	CHARCOAL/WOOD:						
	Acer	Charcoal		1			0.001 g
	Conifer	Charcoal		3			< 0.001 g
	Pseudotsuga menziesii	Charcoal		1			< 0.001 g
	Unidentified ≥ 2mm	Wood				X	0.204 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				12	
	Rock/Gravel					X	Few
	Sand					X	Scant

TABLE 2 (Continued)

Sample No.	Identification	Part	Charred W	Charred F	Uncharred W	Uncharred F	Weights/ Comments
92802-3-1	Liters Floated						2.30 L
7' - 7' 5"	Light Fraction Weight						0.89 g
	FLORAL REMAINS:						
	Picea sitchensis	Needle		2			< 0.001 g
	Unidentified plant fibers					X	0.003 g
	Rootlets					X	Very few
	CHARCOAL/WOOD:						
	Conifer - rounded	Charcoal		8			0.011 g
	Conifer	Charcoal		11			0.003 g
	Tsuga - rounded	Charcoal		1			0.009 g
	Unidentified ≥ 0.5 mm	Charcoal		X			0.008 g
	Unidentified bark			1			0.008 g
	NON-FLORAL REMAINS:						
	Rock/Gravel					X	Moderate
	Sand					X	Abundant
92802-3-2	Liters Floated						1.00 L
5' - 5' 6"	Light Fraction Weight						3.05 g
	FLORAL REMAINS:						
	Bark			6			0.010 g
	Rootlets					X	Few
	Sclerotia				X	X	Few
	CHARCOAL/WOOD:						
	Conifer	Charcoal		5			0.016 g
	Conifer - rounded	Charcoal		4			0.027 g
	Abies - rounded	Charcoal		4			0.023 g
	Unidentified ≥ 1mm	Charcoal		X			0.072 g
	NON-FLORAL REMAINS:						
	Insert	Chitin				2	
	Sand					X	Few
93002-3-1	Liters Floated						2.10 L
3' 9" - 4' 4"	Light Fraction Weight						4.63 g
	FLORAL REMAINS:						
	Unidentified bark ≥ 2mm					32	0.319 g
	Unidentified bark < 2mm					X	Moderate

TABLE 2 (Continued)

Sample No.	Identification	Part	Charred W	Charred F	Uncharred W	Uncharred F	Weights/ Comments
	Bark with orange coating ≥ 2mm					42	0.457 g
	Bark with orange coating < 2mm					X	Moderate
	Rootlets					X	Numerous
	Sclerotia					X	Few
	CHARCOAL/WOOD:						
	Conifer	Charcoal		10			< 0.001 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				17	
	Rock/Gravel					X	Moderate
	Sand					X	Moderate
92902-1-1	Liters Floated						2.20 L
15'	Light Fraction Weight						7.88 g
	FLORAL REMAINS:						
	Conifer	Needle		1			< 0.001 g
	Picea	Needle				X	Few
	Tsuga	Needle			2		
	Rootlets					X	Numerous
	CHARCOAL/WOOD:						
	Conifer	Charcoal		12			0.006 g
	Conifer - rounded, coated	Charcoal		5			0.003 g
	Unidentified ≥ 0.5 mm	Charcoal		X			0.030 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				18	
	Sand					X	Few
92902-1-2	Liters Floated						2.20 L
10'	Light Fraction Weight						14.43 g
	FLORAL REMAINS:						
	Unidentified plant fibers					X	Moderate
	Rootlets					X	Moderate
	Sclerotia					X	Few
	CHARCOAL/WOOD:						
	Alnus	Charcoal		1			0.006 g

TABLE 2 (Continued)

Sample No.	Identification	Part	Charred W	Charred F	Uncharred W	Uncharred F	Weights/ Comments
	Conifer	Charcoal		15			0.013 g
	Conifer - rounded	Charcoal		4			0.003 g
	Tsuga	Charcoal		1			0.007 g
	Unidentified ≥ 0.5 mm	Charcoal		x			0.030 g
	Bark	Charcoal		18			0.057 g
	NON-FLORAL REMAINS:						
	Insect fecal pellet		1				
	Insect	Chitin				60	
	Rodent fecal pellet				1	X	Few
	Sand					X	Few
92902-1-3	Liters Floated						2.60 L
	Light Fraction Weight						5.10 g
	FLORAL REMAINS:						
	Rootlets					X	Few
	Sclerotia					X	Few
	CHARCOAL/WOOD:						
	Conifer	Charcoal		12			0.008 g
	Conifer - rounded, coated	Charcoal		5			0.005 g
	Unidentified ≥ 0.5 mm	Charcoal		X			< 0.001 g
	NON-FLORAL REMAINS:						
	Coal ≥ 0.5 mm					71	
	Insect					3	
	Sand					X	Moderate

W = Whole
F = Fragment
X = Presence noted in sample
g = grams

TABLE 3
INDEX OF MACROFLORAL REMAINS RECOVERED FROM THE
QUINAULT RIVER GEOMORPHIC STUDY

Scientific Name	Common Name
FLORAL REMAINS:	
Alnus	Alder
Calandrinia	Calandrinia, Red maids
Caryophyllaceae	Pink family
Chenopodium	Goosefoot
Conifer	Cone-bearing, gymnospermous trees and shrubs, mostly evergreens, including the pine, spruce, fir, juniper, cedar, yew, and cypress
Picea sitchensis	Sitka spruce
Picea	Spruce
Thuja plicata	Western red cedar
Rubus	Raspberry, Blackberry, etc.
Sambucus	Elderberry
Sclerotia	Resting structures of mycorrhizae fungi
CHARCOAL/WOOD:	
Acer	Maple, Box elder
Alnus	Alder
Conifer	Cone-bearing, gymnospermous trees and shrubs, mostly evergreens, including the pine, spruce, fir, juniper, cedar, yew, and cypress
Picea	Spruce
Pseudotsuga menziesii	Douglas-fir
Thuja	
Tsuga	Hemlock
Populus	Aspen, Cottonwood

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EXAMINATION OF SEDIMENT FOR RADIOCARBON DATABLE MATERIAL FROM ALONG THE QUINAULT RIVER, WASHINGTON

By

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Paleo Research Institute Technical Report 04-103

Prepared For

Bureau of Reclamation
Reclamation Service Center
Denver, Colorado

October 2004

INTRODUCTION

A single sediment sample from along the Quinault River in the western Olympic Peninsula, Washington, was floated to recover organic fragments suitable for radiocarbon analysis. This sample was recovered from a natural exposure along the river and is believed to represent silt that was likely deposited in Lake Quinault when it was higher than at present. Botanic components and detrital charcoal were identified, and potentially radiocarbon datable material was separated.

METHODS

The sediment sample was water-screened through a 250-micron mesh sieve and allowed to dry. The dried sample was scanned under a binocular stereo microscope at a magnification of 10x. Charcoal fragments were separated and examined under a binocular microscope at a magnification of 70x. Macrofloral remains, including charcoal, were identified using manuals (Core, et al. 1976; Martin and Barkley 1961; Panshin and Zeeuw 1980; Petrides and Petrides 1992) and by comparison with modern and archaeological references. The term "seed" is used to represent seeds, achenes, caryopses, and other disseminules. Because charcoal and possibly other botanic remains were to be sent for radiocarbon analysis, clean laboratory conditions were used during water-screening and identification to avoid contamination. All instruments were washed between samples, and samples were protected from contact with modern charcoal.

DISCUSSION

The Quinault River study site is located near river kilometer 2.5 (measured upstream from Lake Quinault). This section of the Quinault River drains the western Olympic Mountains and flows into Lake Quinault, which is dammed by a glacial moraine. Local vegetation in the area is dominated by a variety of riparian plants, including alder (*Alnus*), cottonwood (*Populus*), maple (*Acer*), and grasses (Poaceae).

Sample 81904-1 was collected from silt in a natural exposure at a depth of 2.6 m (Table 1). This sample contained a few fragments of conifer charcoal weighing 0.005 g that can be submitted for AMS radiocarbon analysis (Table 2, Table 3). Several types of uncharred plant remains and wood fragments reflect components of the modern vegetation community. The sample also yielded a few insect chitin fragments.

SUMMARY AND CONCLUSIONS

Flotation of sediment from a natural exposure along the Quinault River in the western Olympic Peninsula, Washington, resulted in recovery of conifer charcoal that can be sent for AMS radiocarbon analysis. Conifers likely are found growing in the Olympic Mountains, which are drained by the Quinault River.

TABLE 1
PROVENIENCE DATA FOR A SINGLE SAMPLE
FROM ALONG THE QUINAULT RIVER, WASHINGTON

Sample No.	Depth	Provenience/ Description	Analysis
81904-1	2.6 m	Bulk sediment in a natural exposure along the Quinault River upstream of Lake Quinault; from silt believed to have been deposited in the lake when it was higher than at present	Float/Charcoal ID prior to C-14 analysis

TABLE 2
MACROFLORAL REMAINS FROM ALONG THE QUINAULT RIVER, WASHINGTON

Sample No.	Identification	Part	Charred W	Charred F	Uncharred W	Uncharred F	Weights/ Comments
81904-1	Volume Water-screened						<0.10 L
	Water-screened Sample Weight						4.20 g
	FLORAL REMAINS:						
	Abies/Pseudotsuga	Needle			4	16*	
	Betula	Seed			112*		
	Carex	Seed			1		
	Caryophyllaceae	Seed			1	1	
	Picea	Needle			10	56*	
	Potentilla	Seed			1		
	Unidentified deciduous	Leaf				X	Moderate
	Moss	Leaf/ Branch				X	Few
	Rootlets					X	Moderate
	CHARCOAL/WOOD:						
	Conifer	Charcoal		5			0.005 g
	Conifer	Wood				4	0.015 g
	Conifer twig	Wood				1	0.003 g
	Abies	Wood				1	0.003 g
	Pseudotsuga menziesii	Wood				1	0.006 g
	NON-FLORAL REMAINS:						
	Insect	Chitin				20	

W = Whole
F = Fragment
X = Presence noted in sample
L = Liters
g = grams
* = Estimated frequency

TABLE 3
INDEX OF MACROFLORAL REMAINS RECOVERED
FROM ALONG THE QUINAULT RIVER, WASHINGTON

Scientific Name	Common Name
FLORAL REMAINS:	
Abies/Pseudotsuga	Fir/Douglas fir
Betula	Birch
Carex	Sedge
Caryophyllaceae	Pink family
Picea	Spruce
Potentilla	Cinquefoil
CHARCOAL/WOOD:	
Conifer	Cone-bearing, gymnospermous trees and shrubs, mostly evergreens, including the pine, spruce, fir, juniper, cedar, yew, and cypress
Abies	Fir
Pseudotsuga menziesii	Douglas-fir

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FROM: Darden Hood, Director (mailto:mailto:dhood@radiocarbon.com)
(This is a copy of the letter being mailed. Invoices/receipts follow only by mail.)

October 16, 2003

Dr. Lucy Piety
Bureau of Reclamation
Denver Federal Center
D-8330
P.O. Box 25007
Denver, CO 80225
USA

RE: Radiocarbon Dating Results For Samples 92502-1-2CO, 92502-1-3PI, 92502-2-2CO, 92502-3-1CO, 92502-3-2CO, 92702-4-1PO, 92802-3-1CO, 92802-3-2CO, 92902-1-1CO, 92902-1-2CO, 92902-1-3CO

Dear Dr. Piety:

Enclosed are the radiocarbon dating results for 11 samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses went normally. The report sheet also contains the method used, material type, applied pretreatments and, where applicable, the two sigma calendar calibration range.

As always, this report has been both mailed and sent electronically. All results (excluding some inappropriate material types) which are less than about 20,000 years BP and more than about ~250 BP include this calendar calibration page (also digitally available in Windows metafile (wmf) format upon request). The calibrations are calculated using the newest (1998) calibration database with references quoted on the bottom of each page. Multiple probability ranges may appear in some cases, due to short term variations in the atmospheric 14C contents at certain time periods. Examining the calibration graphs will help you understand this phenomenon. Don't hesitate to contact us if you have questions about calibration.

We analyzed these samples on a sole priority basis. No students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

Information pages are also enclosed with the mailed copy of this report. If you have any specific questions about the analyses, please do not hesitate to contact us.

Our invoice is enclosed. Please, forward it to the appropriate officer or send VISA change authorization. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood

Dr. Lucy Piety | Report Date: 10/16/2003

Bureau of Reclamation | Material Received: 9/25/2003

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 183376 SAMPLE : 92502-1-2CO ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1290 to 1410 (Cal BP 660 to 540)	620 +/- 40 BP	-24.6 o/oo	630 +/- 40 BP
Beta - 183377 SAMPLE : 92502-1-3PI ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1010 to 1180 (Cal BP 940 to 760)	970 +/- 40 BP	-26.2 o/oo	950 +/- 40 BP
Beta - 183378 SAMPLE : 92502-2-2CO ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 410 to 600 (Cal BP 1540 to 1350)	1560 +/- 40 BP	-24.9 o/oo	1560 +/- 40 BP
Beta - 183379 SAMPLE : 92502-3-1CO ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1060 to 1080 (Cal BP 890 to 860) AND Cal AD 1150 to 1270 (Cal BP 800 to 680)	860 +/- 40 BP	-26.4 o/oo	840 +/- 40 BP
Beta - 183380 SAMPLE : 92502-3-2CO ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 660 to 790 (Cal BP 1290 to 1160)	1300 +/- 40 BP	-25.5 o/oo	1290 +/- 40 BP

Dr. Lucy Piety

Report Date: 10/16/2003

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 183381	270 +/- 40 BP	-25.5 o/oo	260 +/- 40 BP

SAMPLE : 92702-4-1PO
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1520 to 1590 (Cal BP 430 to 360) AND Cal AD 1620 to 1670 (Cal BP 330 to 280)
Cal AD 1770 to 1800 (Cal BP 180 to 150) AND Cal AD 1940 to 1950 (Cal BP 10 to 0)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 183382	3250 +/- 50 BP	-21.8 o/oo	3300 +/- 50 BP

SAMPLE : 92802-3-1CO
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 1690 to 1450 (Cal BP 3640 to 3400)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 183383	3720 +/- 40 BP	-24.6 o/oo	3730 +/- 40 BP

SAMPLE : 92802-3-2CO
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 2270 to 2260 (Cal BP 4220 to 4210) AND Cal BC 2220 to 2020 (Cal BP 4170 to 3970)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 183384	2480 +/- 40 BP	-26.9 o/oo	2450 +/- 40 BP

SAMPLE : 92902-1-1CO
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 780 to 400 (Cal BP 2730 to 2350)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 183385	3040 +/- 40 BP	-24.6 o/oo	3050 +/- 40 BP

SAMPLE : 92902-1-2CO
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 1410 to 1200 (Cal BP 3360 to 3150)

Dr. Lucy Piety

Report Date: 10/16/2003

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 183386	5650 +/- 50 BP	-26.5 o/oo	5630 +/- 50 BP

SAMPLE : 92902-1-3CO
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 4550 to 4350 (Cal BP 6500 to 6300)

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.6:lab. mult=1)

Laboratory number: **Beta-183376**

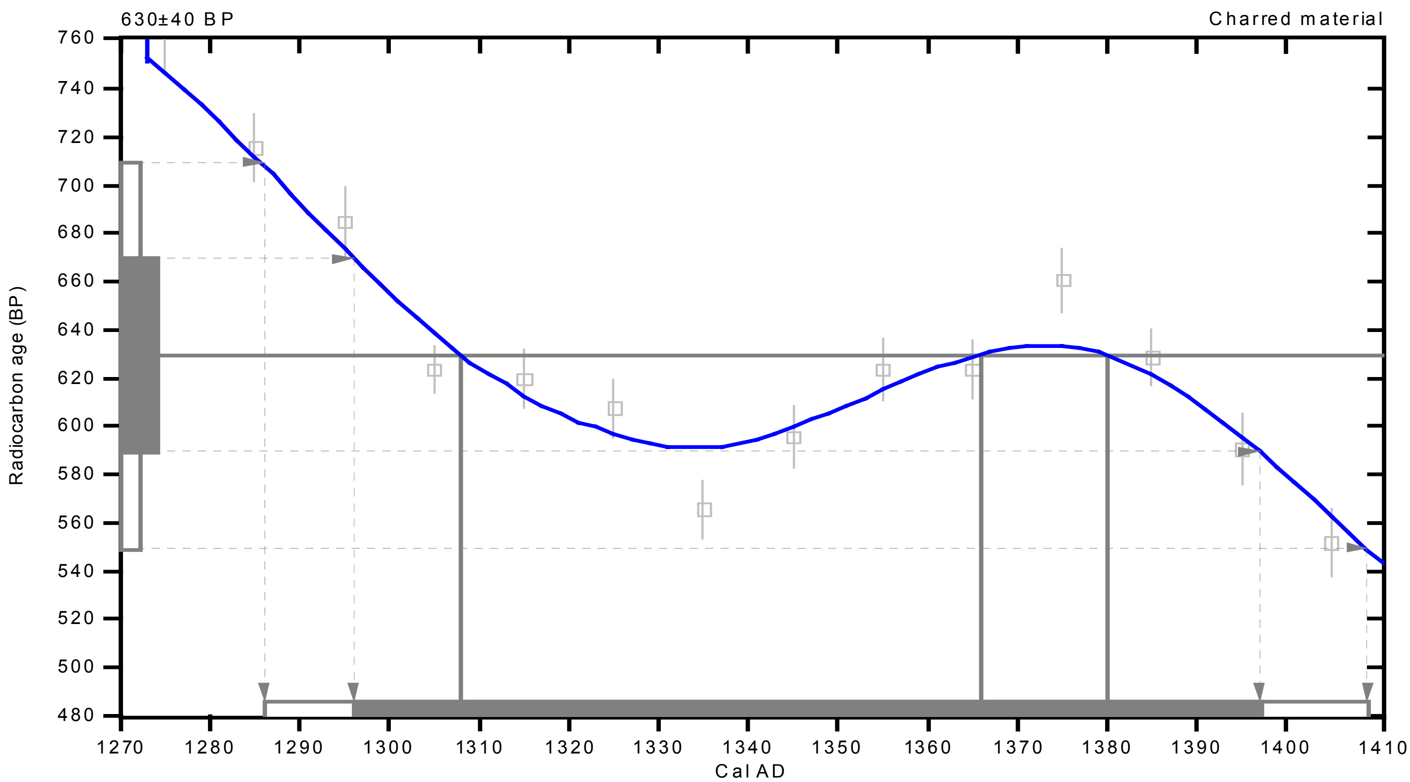
Conventional radiocarbon age: **630±40 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 1290 to 1410 (Cal BP 660 to 540)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 1310 (Cal BP 640) and
Cal AD 1370 (Cal BP 580) and
Cal AD 1380 (Cal BP 570)

1 Sigma calibrated result: (68% probability) Cal AD 1300 to 1400 (Cal BP 650 to 550)



References:

Database used

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Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.2:lab. mult=1)

Laboratory number: **Beta-183377**

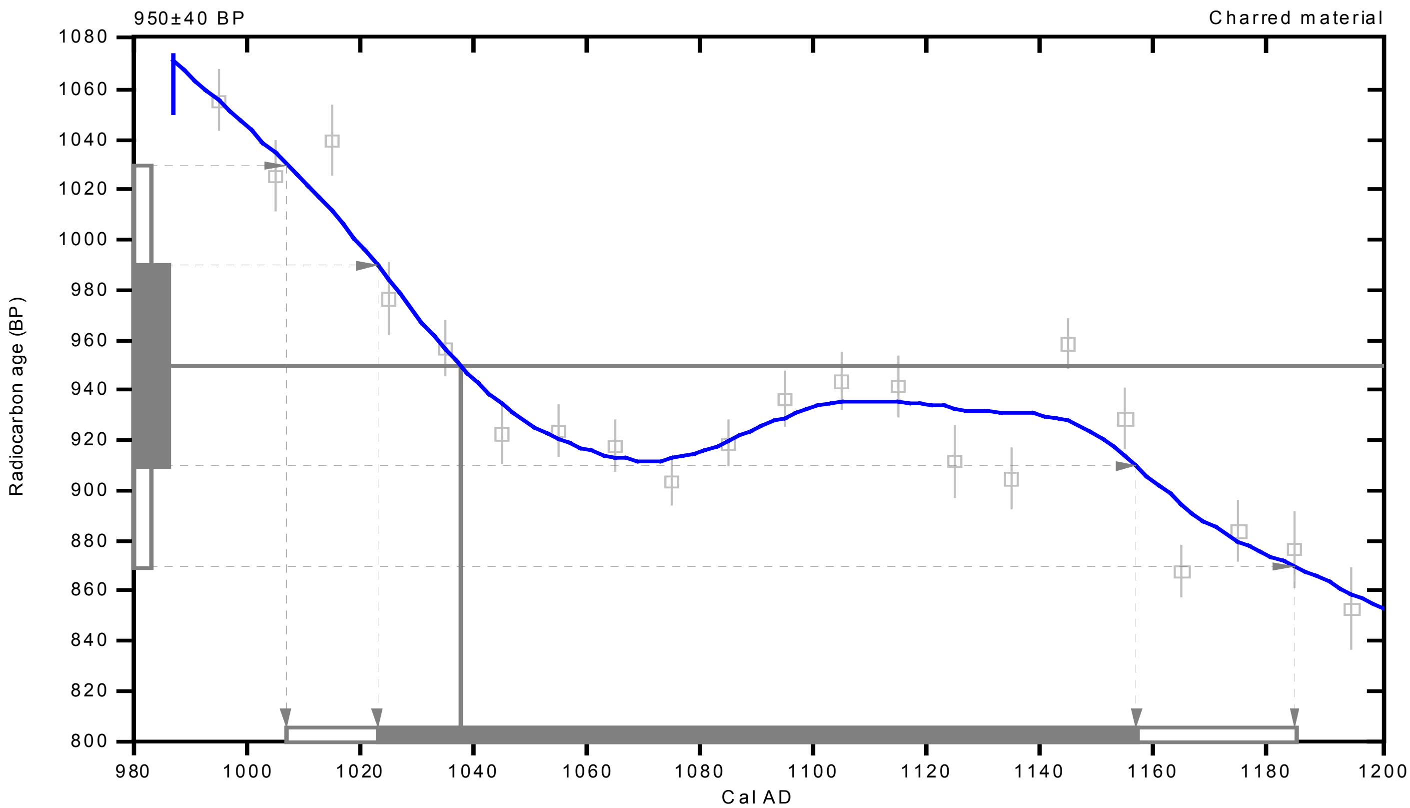
Conventional radiocarbon age: **950±40 BP**

2 Sigma calibrated result: **Cal AD 1010 to 1180 (Cal BP 940 to 760)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 1040 (Cal BP 910)

1 Sigma calibrated result: Cal AD 1020 to 1160 (Cal BP 930 to 790)
(68% probability)



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

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

Laboratory number: **Beta-183378**

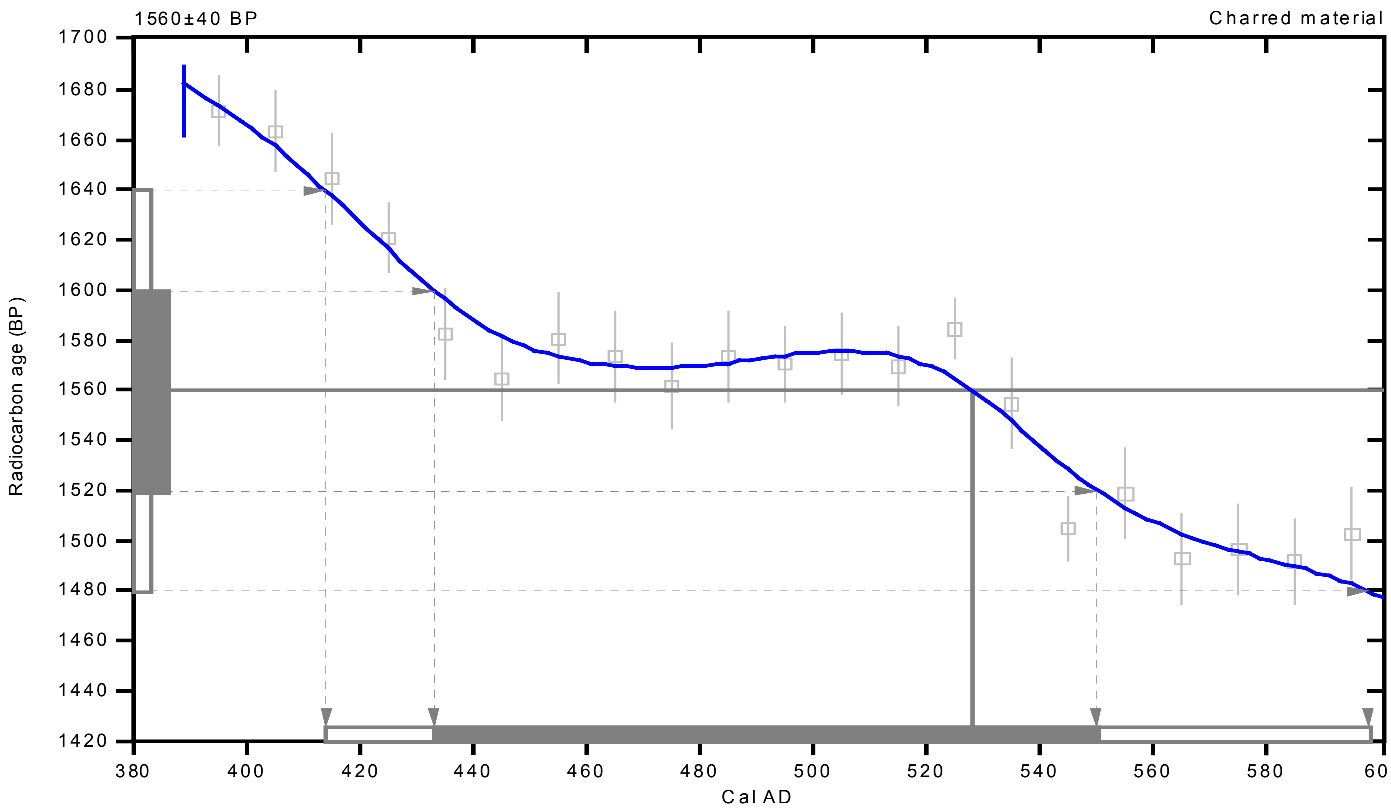
Conventional radiocarbon age: **1560±40 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 410 to 600 (Cal BP 1540 to 1350)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 530 (Cal BP 1420)

1 Sigma calibrated result: (68% probability) Cal AD 430 to 550 (Cal BP 1520 to 1400)



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Database used

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.4:lab. mult=1)

Laboratory number: **Beta-183379**

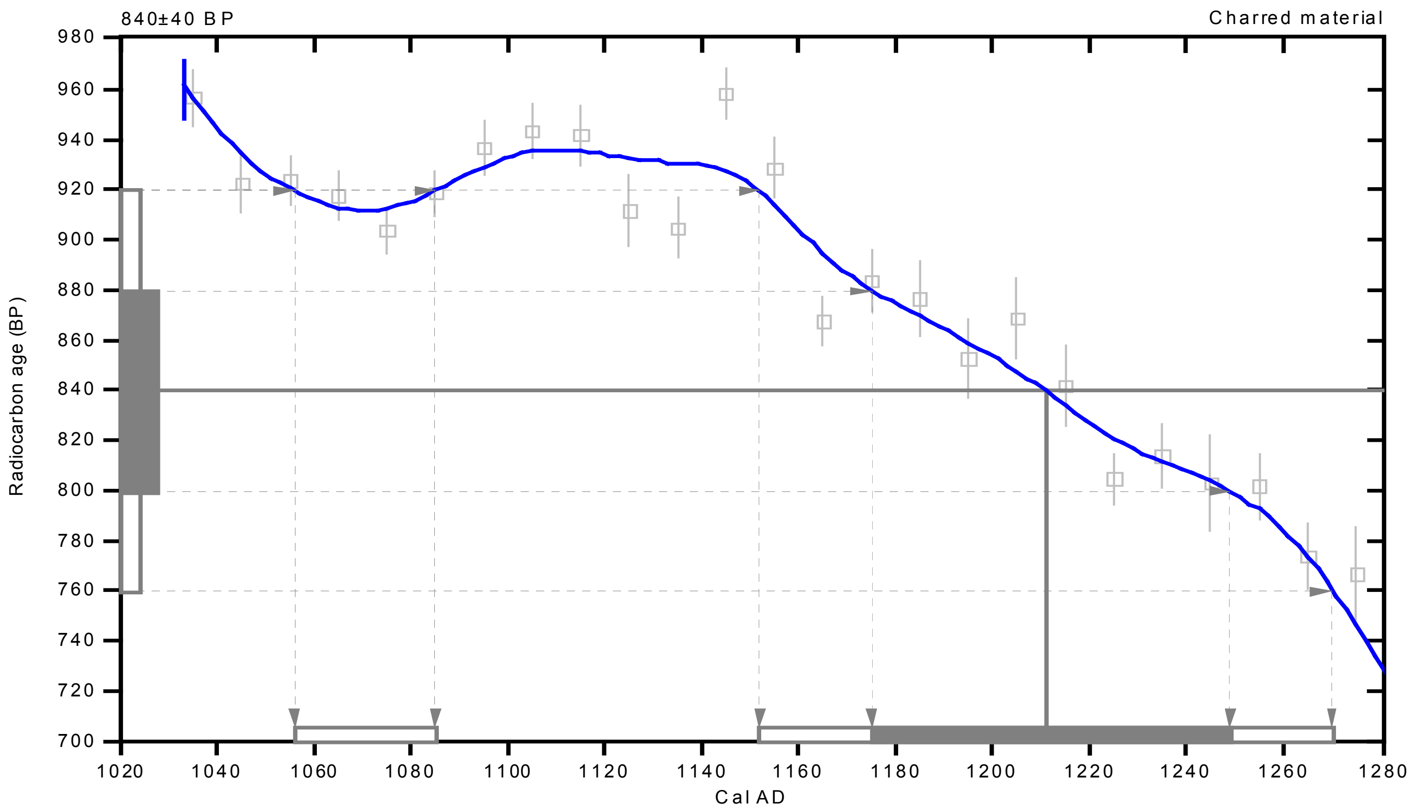
Conventional radiocarbon age: **840±40 BP**

2 Sigma calibrated results: **Cal AD 1060 to 1080 (Cal BP 890 to 860) and**
(95% probability) **Cal AD 1150 to 1270 (Cal BP 800 to 680)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1210 (Cal BP 740)

1 Sigma calibrated result: Cal AD 1180 to 1250 (Cal BP 780 to 700)
(68% probability)



References:

Database used

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

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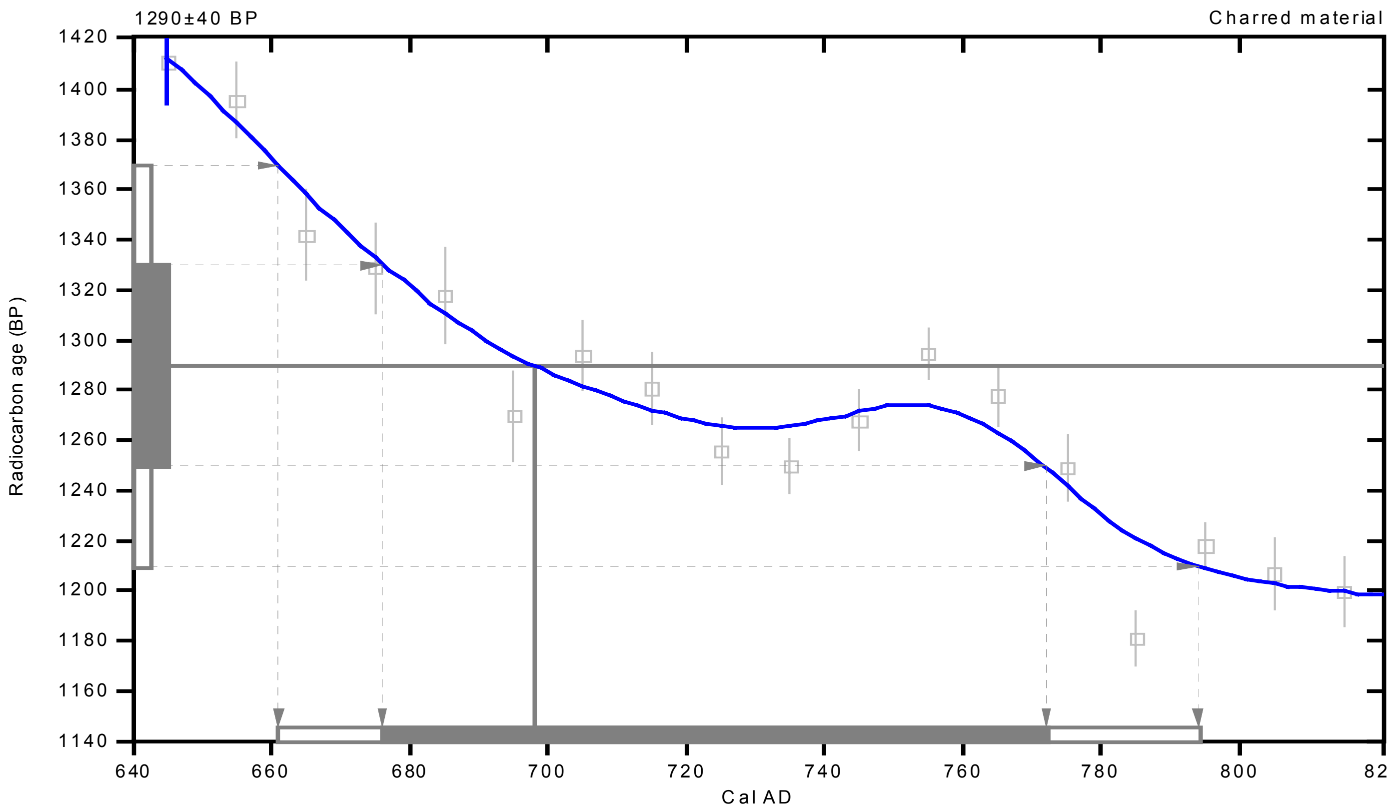
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.5:lab. mult=1)

Laboratory number:	**Beta-183380**
Conventional radiocarbon age:	**1290±40 BP**
2 Sigma calibrated result: (95% probability)	**Cal AD 660 to 790 (Cal BP 1290 to 1160)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 700 (Cal BP 1250)
1 Sigma calibrated result: (68% probability)	Cal AD 680 to 770 (Cal BP 1270 to 1180)



References:

Database used

Calibration Database

Editorial Comment

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

INTCAL98 Radiocarbon Age Calibration

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.5:lab. mult=1)

Laboratory number: **Beta-183381**

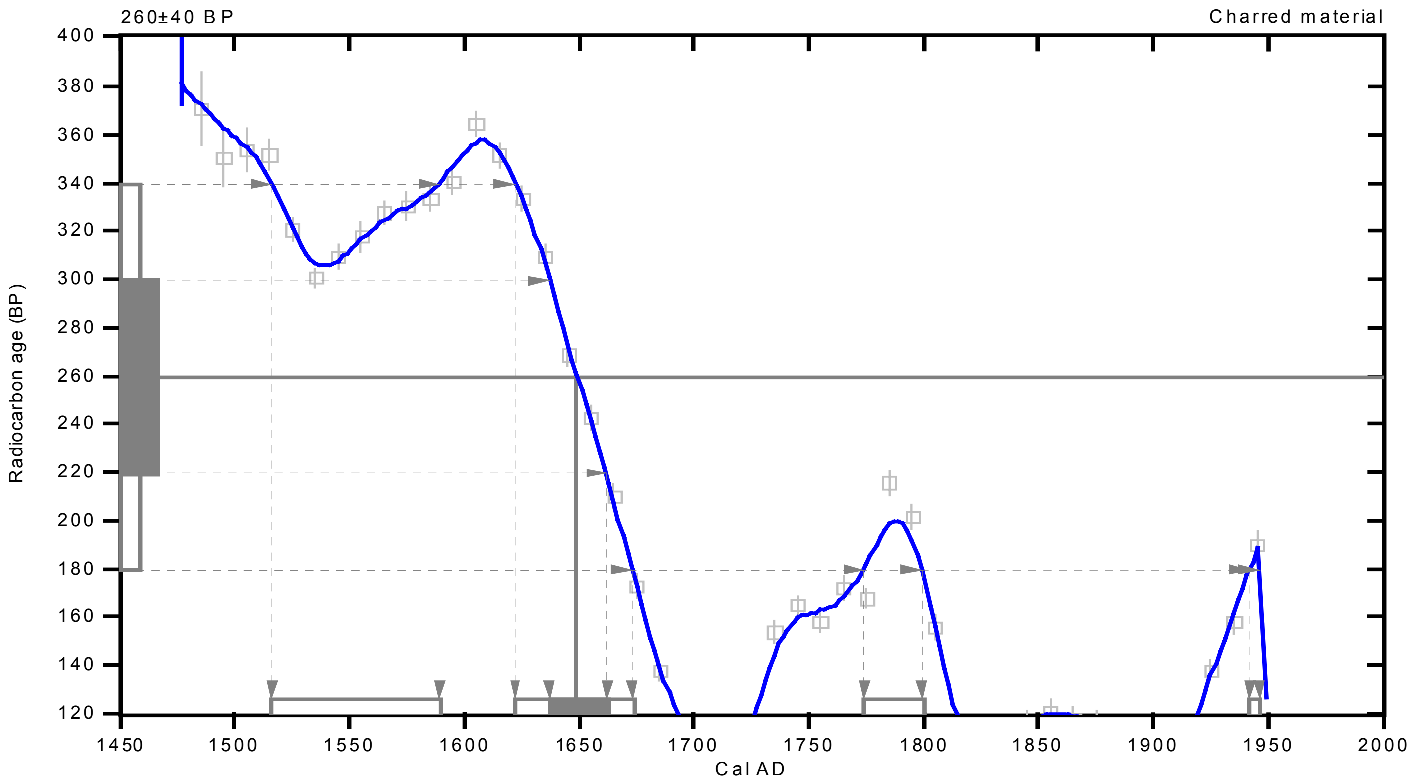
Conventional radiocarbon age: **260±40 BP**

2 Sigma calibrated results: **Cal AD 1520 to 1590 (Cal BP 430 to 360) and**
(95% probability) **Cal AD 1620 to 1670 (Cal BP 330 to 280) and**
Cal AD 1770 to 1800 (Cal BP 180 to 150) and
Cal AD 1940 to 1950 (Cal BP 10 to 0)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 1650 (Cal BP 300)

1 Sigma calibrated result: Cal AD 1640 to 1660 (Cal BP 310 to 290)
(68% probability)



References:
Database used

Calibration Database
Editorial Comment
Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii
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Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-21.8:lab. mult=1)

Laboratory number: **Beta-183382**

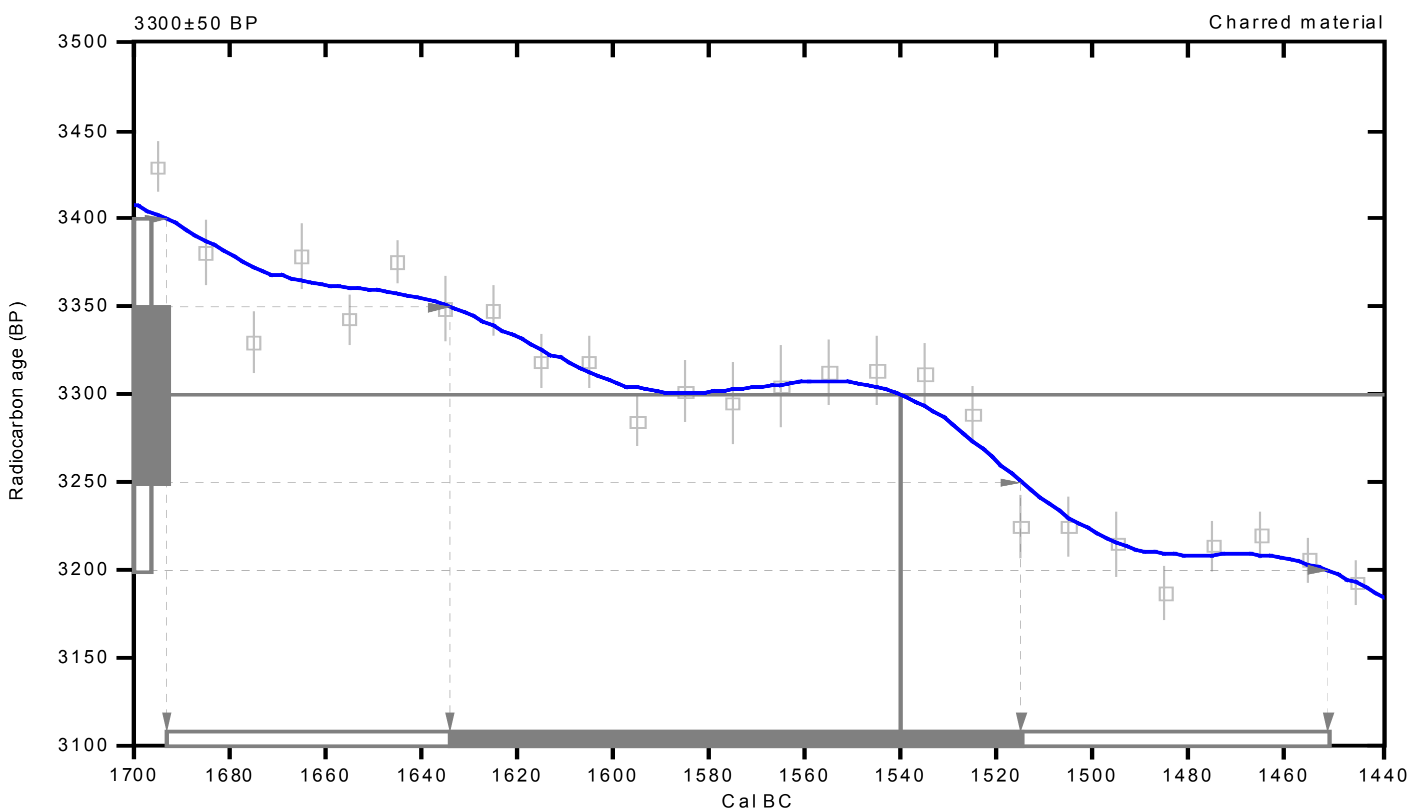
Conventional radiocarbon age: **3300±50 BP**

2 Sigma calibrated result: **Cal BC 1690 to 1450 (Cal BP 3640 to 3400)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 1540 (Cal BP 3490)

1 Sigma calibrated result: Cal BC 1630 to 1520 (Cal BP 3580 to 3460)
(68% probability)



References:

Database used

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
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.6:lab. mult=1)

Laboratory number: **Beta-183383**

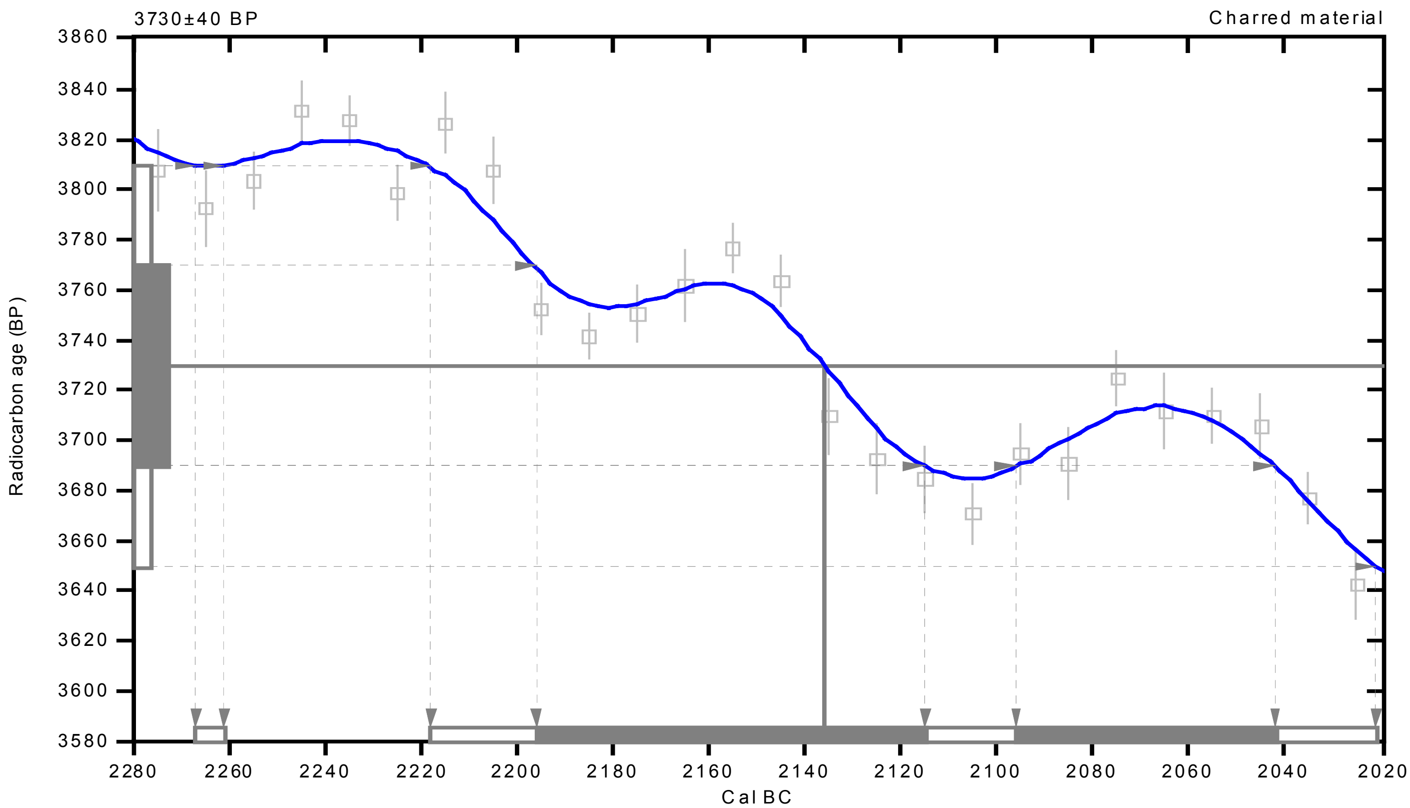
Conventional radiocarbon age: **3730±40 BP**

2 Sigma calibrated results: (95% probability) **Cal BC 2270 to 2260 (Cal BP 4220 to 4210) and Cal BC 2220 to 2020 (Cal BP 4170 to 3970)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 2140 (Cal BP 4090)

1 Sigma calibrated results: (68% probability) Cal BC 2200 to 2120 (Cal BP 4150 to 4060) and Cal BC 2100 to 2040 (Cal BP 4050 to 3990)



References:

Database used

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INTCAL98 Radiocarbon Age Calibration
Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.9:lab. mult=1)

Laboratory number: **Beta-183384**

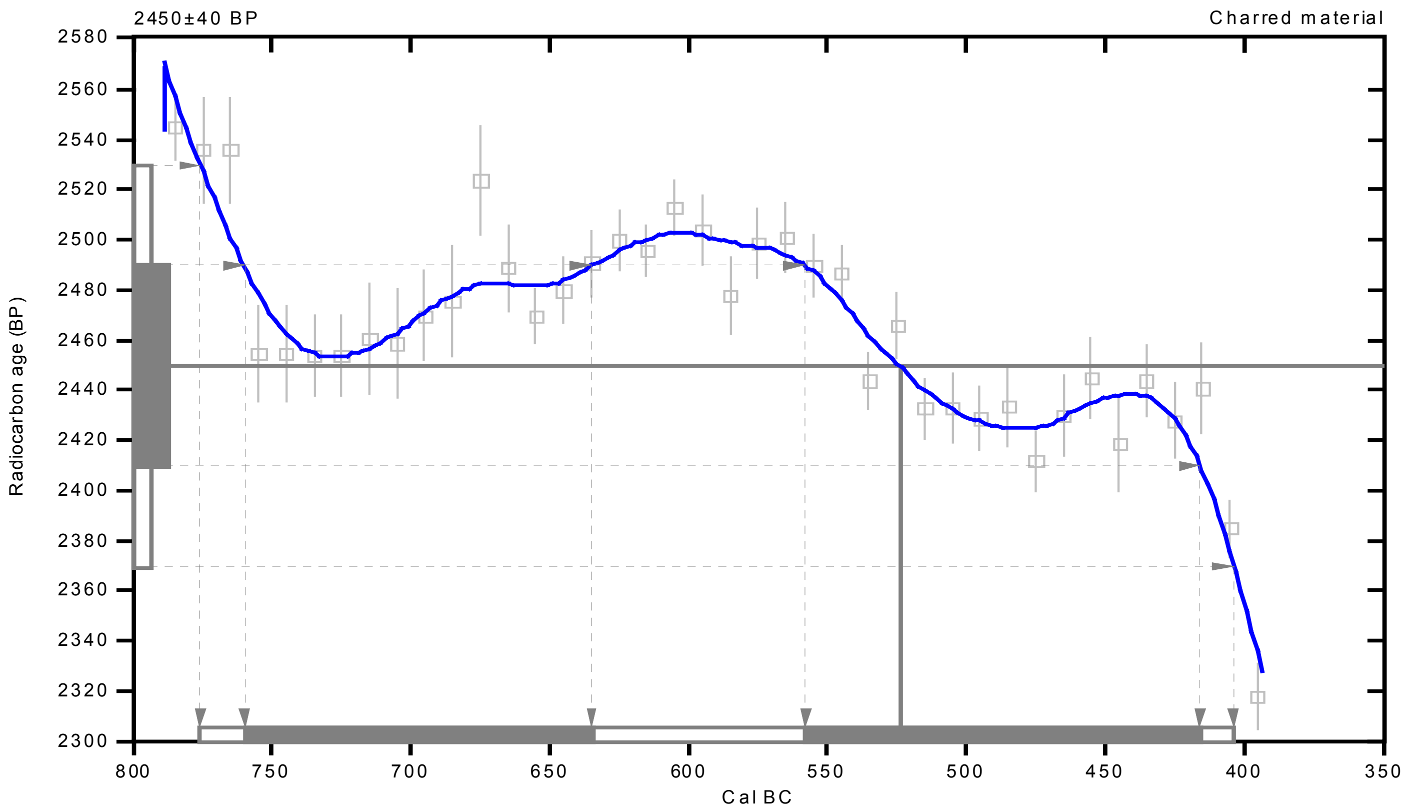
Conventional radiocarbon age: **2450±40 BP**

2 Sigma calibrated result: **Cal BC 780 to 400 (Cal BP 2730 to 2350)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 520 (Cal BP 2470)

1 Sigma calibrated results: Cal BC 760 to 640 (Cal BP 2710 to 2580) and
(68% probability) Cal BC 560 to 420 (Cal BP 2510 to 2370)



References:

Database used

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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
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.6:lab. mult=1)

Laboratory number: **Beta-183385**

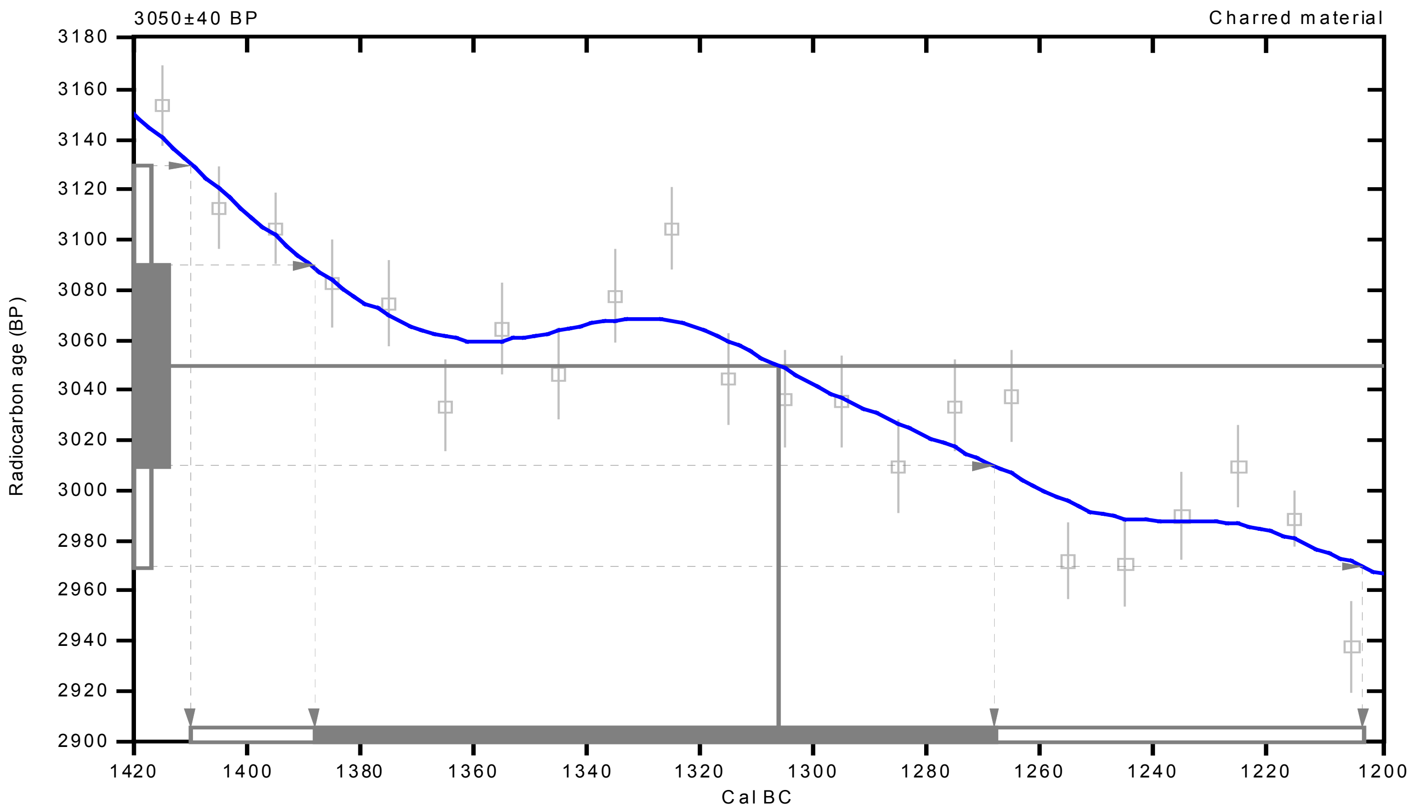
Conventional radiocarbon age: **3050±40 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 1410 to 1200 (Cal BP 3360 to 3150)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 1310 (Cal BP 3260)

1 Sigma calibrated result: (68% probability) Cal BC 1390 to 1270 (Cal BP 3340 to 3220)



References:

Database used

Calibration Database

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

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

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

Laboratory number: **Beta-183386**

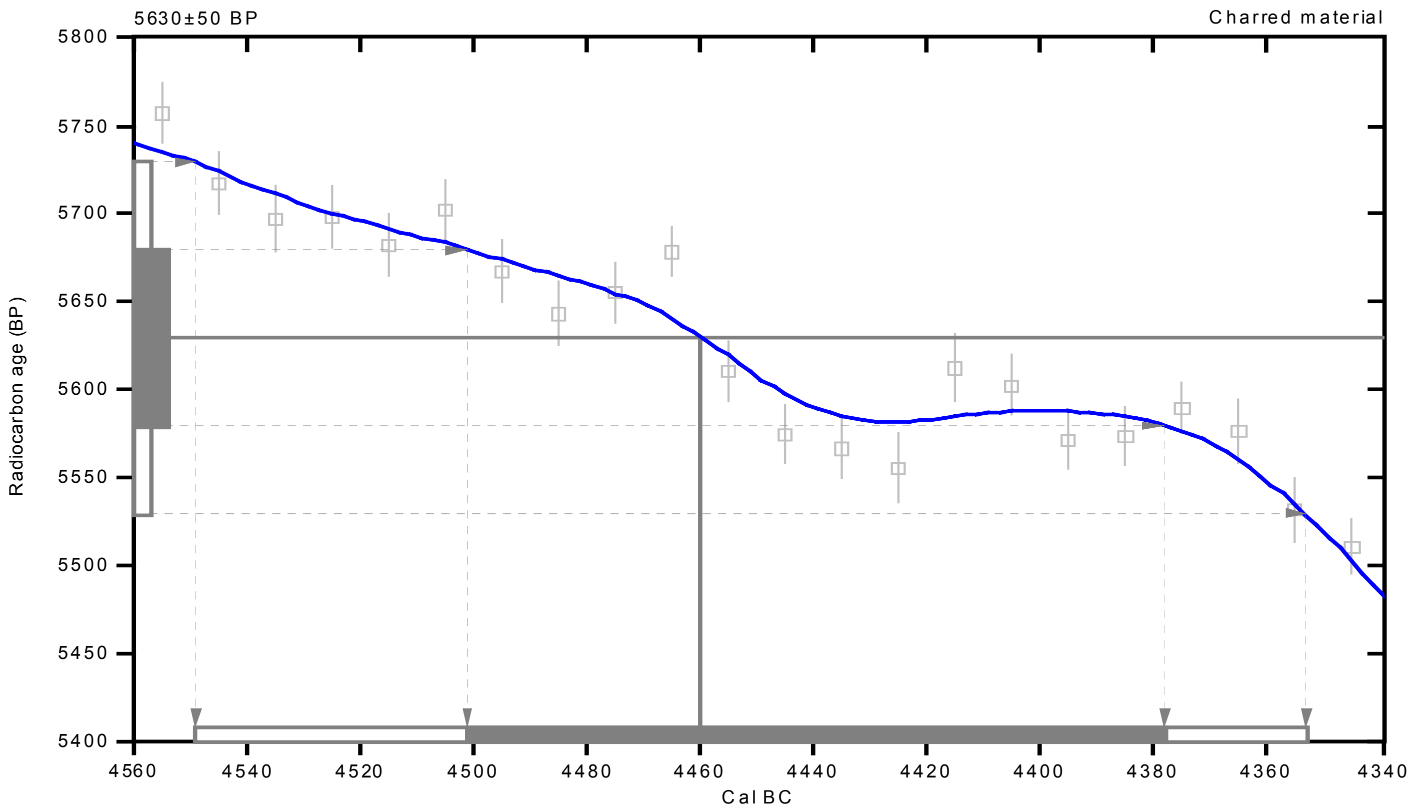
Conventional radiocarbon age: **5630±50 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 4550 to 4350 (Cal BP 6500 to 6300)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 4460 (Cal BP 6410)

1 Sigma calibrated result: (68% probability) Cal BC 4500 to 4380 (Cal BP 6450 to 6330)



References:

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Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii
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FROM: Darden Hood, Director (mailto:mailto:dhood@radiocarbon.com)

(This is a copy of the letter being mailed. Invoices/receipts follow only by mail.)

December 3, 2004

Dr. Lucy Piety
Bureau of Reclamation
Denver Federal Center
D-8330
P.O. Box 25007
Denver, CO 80225
USA

RE: Radiocarbon Dating Result For Sample 81904-1-1CO

Dear Dr. Piety:

Enclosed is the radiocarbon dating result for one sample recently sent to us. It provided plenty of carbon for an accurate measurement and the analysis went normally. As usual, the method of analysis is listed on the report sheet and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analysis. It was analyzed with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

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

Sincerely,

Darden Hood

Dr. Lucy Piety	Report Date: 12/3/2004
Bureau of Reclamation	Material Received: 11/2/2004

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 197492	1050 +/- 40 BP	-23.4 o/oo	1080 +/- 40 BP

SAMPLE : 81904-1-1CO
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 890 to 1020 (Cal BP 1060 to 930)

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

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

Laboratory number: **Beta-197492**

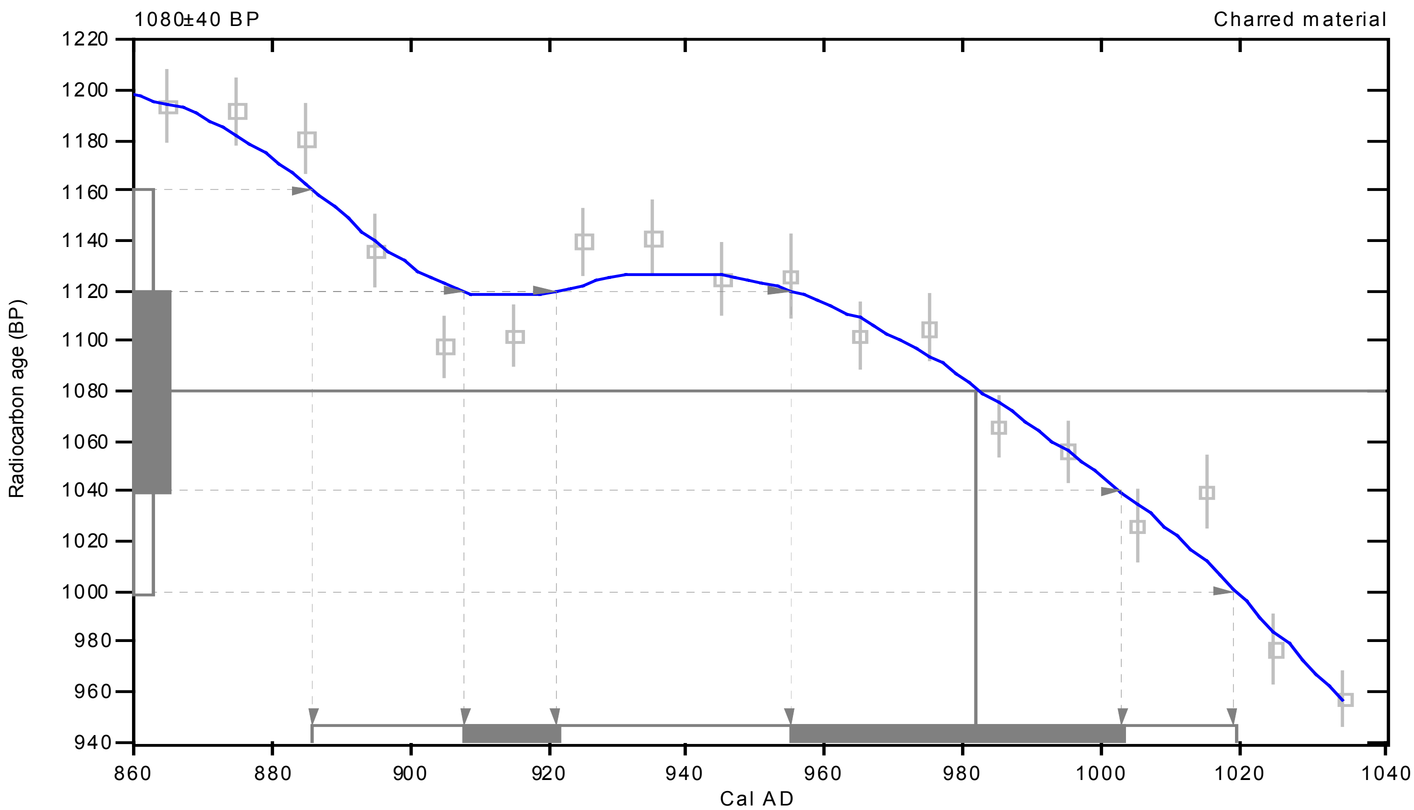
Conventional radiocarbon age: **1080±40 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 890 to 1020 (Cal BP 1060 to 930)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 980 (Cal BP 970)

1 Sigma calibrated results: (68% probability) Cal AD 910 to 920 (Cal BP 1040 to 1030) and Cal AD 960 to 1000 (Cal BP 1000 to 950)



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

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

Variables used in the calculation of age calibration → (Variables: est. C13/C12=-25:lab. mult=1)

Laboratory number: **Beta-123456**

Conventional radiocarbon age[1]: **2400±60 BP** ← The uncalibrated Conventional Radiocarbon Age (± 1 sigma)

The calendar age range in both calendar years (AD or BC) and in Radiocarbon Years (BP) → **2 Sigma calibrated result: (95% probability)** **Cal BC 770 to 380 (Cal BP 2720 to 2330)**

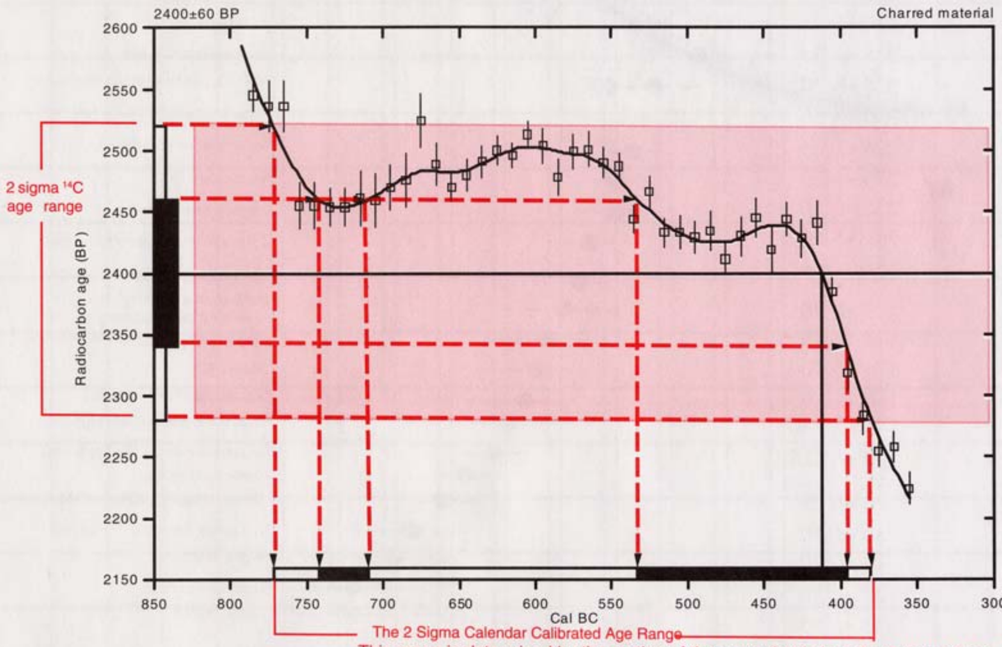
[1] C13/C12 ratio estimated

Intercept data

The intercept between the average radiocarbon age and the calibrated curve time scale. This value is illustrative and should not be used by itself.

Intercept of radiocarbon age with calibration curve: Cal BC 410 (Cal BP 2360)

1 Sigma calibrated result: (68% probability) Cal BC 740 to 710 (Cal BP 2690 to 2660) and Cal BC 535 to 395 (Cal BP 2485 to 2345)



The 2 Sigma Calendar Calibrated Age Range
This range is determined by the portion of the curve that is in a "box" drawn from the 2 sigma limits on the radiocarbon age. If a section of the curve goes outside of the "box", multiple ranges will occur as shown by the two 1 sigma ranges which occur from sections going outside of a similar "box" which would be drawn at the 1 sigma limits.

References:
Database used
Intcal 98
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
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← References for the calibration data and the mathematics applied to the data. These references, as well as the Conventional Radiocarbon Age and the 13C/12C ratio used should be included in your papers.

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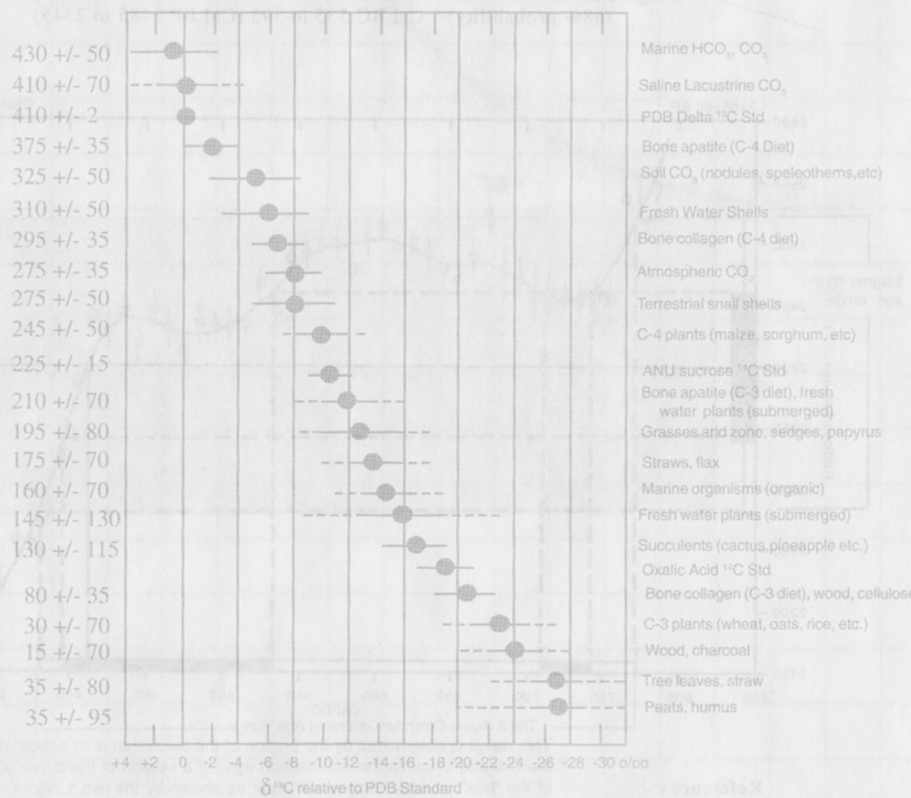
Derivation of a radiometric or accelerator dendro-calibrated (CALENDAR) date requires use of the CONVENTIONAL radiocarbon date (Stuiver and Polach)[1]. The conventional date is a basic radiocarbon date that has been normalized to the modern standard through the use of $^{13}C/^{12}C$ ratios* (analyzed or estimated). The statistical error (+/-) on an analyzed $^{13}C/^{12}C$ value is quite small and does not contribute significantly to the combined error on the date. However, use of an estimated $^{13}C/^{12}C$ ratio for an unknown sample may incur a large combined error term. This is clearly illustrated in the figure below (Gupta & Polach;modifiec by J. Head)[2] where the possible range of $^{13}C/^{12}C$ values for a particular material type may be so large as to preclude any practical application or correction.

In cases where analyzed $^{13}C/^{12}C$ values are not available, we provide (for illustration) dendro-calibrations assuming a mean "chart" value, but without an estimated error term.

Where a sample carbon reservoir different from that modern oxalic acid/wood modern standard is involved (e.g. shell), further reservoir correction must be employed: the variables used in each calibration displayed on each individual calibration sheet.



[1] Suiver, M. and Polsch, H.A., 1977, Discussion: Reporting of 14-C data, Radiocarbon 19, 355-363.

[2] Gupta S.K. and Polach H.A., 1985, Radiocarbon Dating Practices at ANU Handbook, p. 114, Radiocarbon Laboratory, Research School of Pacific Studies, ANU, Canberra

*Radiocarbon is incorporated into various materials by different pathways and this introduces differing degrees of isotopic fractionation. The $^{13}C/^{12}C$ ratio of any material is the millesimal difference of the sample to the carbonate PDB standard and is directly related to the $^{14}C/^{12}C$ ratio. The degree of sample ^{14}C enrichment or depletion then is normalized to that of the modern standard.