

# Bijlage 2 Stobbenribben and Westbroek radiokoolstofdatering

## 1. Radiocarbon dates:

sample	<sup>14</sup> C age (BP)	depth (cm)	number	<sup>14</sup> a (%)
Stobbenribben 1	20		GrA-61962	112.45 ± 0.37
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Stobbenribben 2	35		GrA-61965	143.97 ± 0.42
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Westbroek 1	10		GrA-60711	106.09 ± 0.42
--				
Westbroek 2	18		GrA-60712	117.13 ± 0.46
--				
Westbroek 3	23		GrA-60713	115.59 ± 0.45
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Westbroek 4	27		GrA-60715	95.57 ± 0.39
364 ± 33				
Westbroek 5	33		GrA-60718	96.69 ± 0.40
270 ± 33				

N.B. Here the ages have not yet been rounded (normally the rounding is done based on significant numbers, which is 5 in this case)

## 2. The Bomb peak:

Nuclear bomb testings in the years 1950/60 have put additional <sup>14</sup>C in the atmosphere. The maximum is a factor of roughly 2 in 1963. For that year <sup>14</sup>a = 2 or 200%. It is meaningless to express the ages of samples in BP because those would be expressed as large negative numbers. For that reason the laboratory reports such measures in <sup>14</sup>a (or F<sup>14</sup>C, which is the same).

## 3. Calibration Bomb peak:

For the calibration of modern samples (<sup>14</sup>a > 1) the curve of atmospheric <sup>14</sup>C concentrations is used. This can be done with OxCal but also with Calibomb, which are two well-known web based programs. The plots below (Figures ST1, ST2 and WB1-WB3) show the results for Stobbenribben samples 1 and 2, and for Westbroek samples 1, 2 and 3.

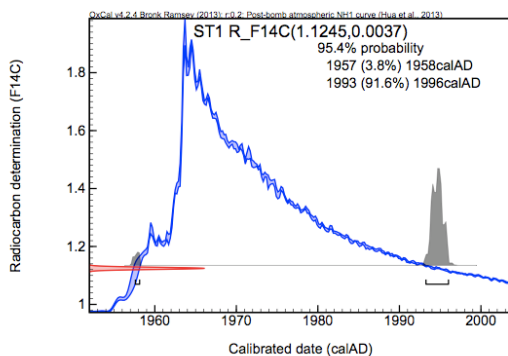


Figure ST1: Calibration curve for Stobbenribben sample 1 (20 cm depth)

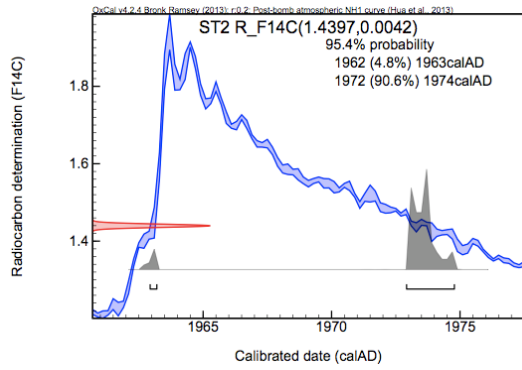


Figure ST2: Calibration curve for Stobbenribben sample 2 (35 cm depth)

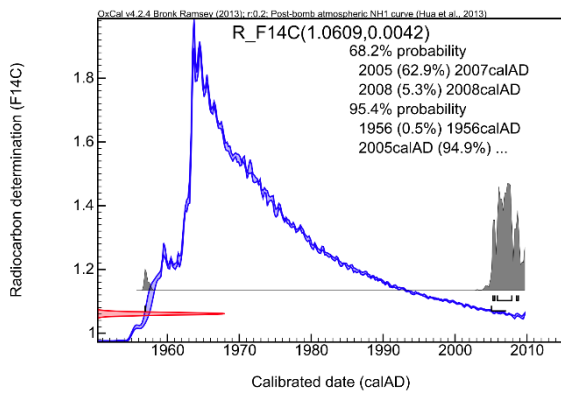


Figure WB1: Calibration curve for Westbroek sample 1 (10 cm depth)

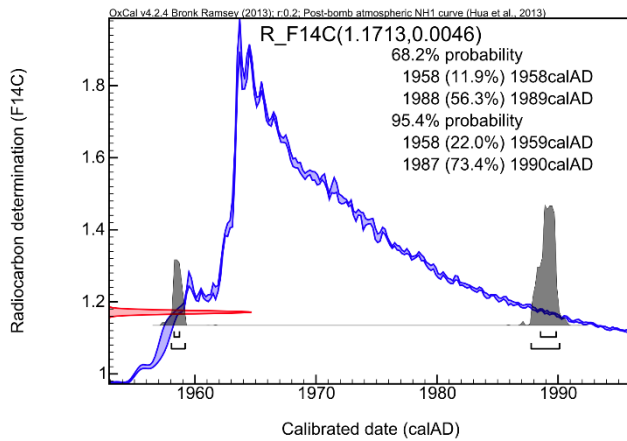


Figure WB2: Calibration curve for Westbroek sample 2 (18 cm depth)

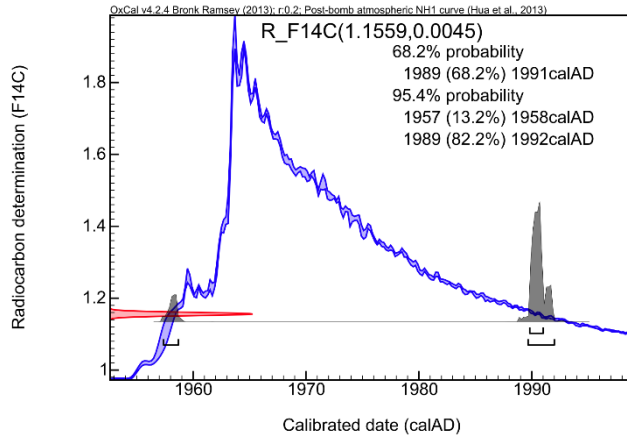


Figure WB3: Calibration curve for Westbroek sample 3 (23 cm depth)

The calibrated calendar year intervals are given in these plots, both for 1-sigma and 2-sigma.

The program uses  $F^{14}C$ , which is the same as  $^{14}a$ .

#### 4. The $^{14}C$ ages:

The  $^{14}C$  concentrations are measured relative to the oxalic acid standard; meaning that the value of the so-called  $^{14}C$  activity ( $^{14}a$ ) for the standard is 1 or 100%, for the half-life it is at 0.5 or 50%, etc.

For Westbroek the  $^{14}C$  activities are listed in the table under  $^{14}a$ . As usual, these are corrected for fractionation. The standard corresponds to 1950 AD. Based on  $^{14}a$  the ages can be calculated according to the exponential equation for radioactive decay:  $N(t) = N(t=0).exp(-It)$ , where  $t$  is the time;  $t=0$  corresponds to 1950 so that  $^{14}a = N(t)/N(t=0)$ . The decay constant  $I$  is related to the half-life time:  $I = \ln(2)/T_{1/2}$ . We use the halflife-time of Libby, 5568 years, so that eventually we get:

$$\text{Age } t = -8033.\ln(^{14}a) \quad \text{That is the conventional } ^{14}C \text{ age BP.}$$

This is how we get to the ages in BP of Westbroek samples 4 and 5.

#### 5. Calibration:

This is the conversion of  $^{14}C$  BP dates into calendar years AD/BC. For samples from before 1950, the conversion is done with calibration graphs, mainly based on dendrochronologically dated tree rings.

This can be done for Westbroek samples 4 and 5. See the plots below, figures WB4 and WB5 (made with OxCal). The plots show the resultant calendar ages intervals (both 1-sigma and 2-sigma).

In the subrecent time (last 3 centuries), the calibration of ages in BP is rather complex because of major fluctuations of  $^{14}C$  production related with changing solar activity and cosmic ray intensity during the Little Ice Age and later.

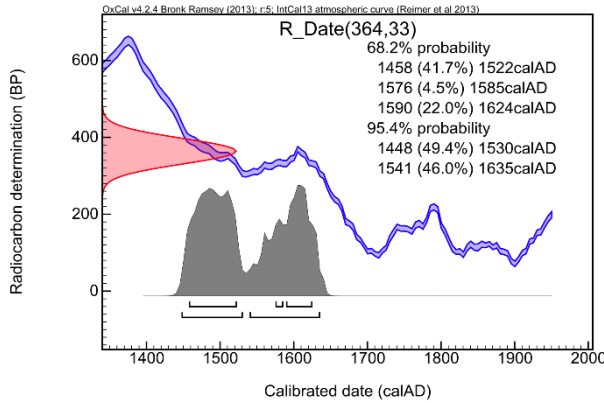


Figure WB4: Calibration curve for Westbroek sample 4 (27 cm depth)

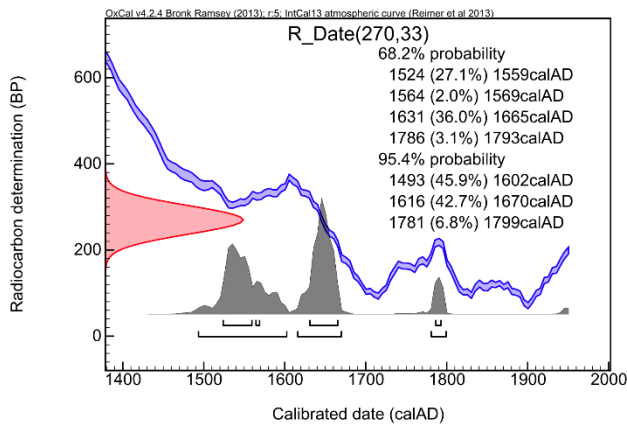


Figure WB5: Calibration curve for Westbroek sample 5 (33 cm depth)

## 6. Summary of the results:

Stobbenribben 1 (20 cm)	1957-1958 or 1993-1996
Stobbenribben 2 (35 cm)	1962-1963 or 1972-1974
Westbroek 1 (10 cm)	1957 or 2005-2008
Westbroek 2 (18 cm)	1958 or 1988-1989
Westbroek 3 (23 cm)	1958 or 1989-1991
Westbroek 4 (27 cm)	1460-1520, 1575-1625
Westbroek 5 (33 cm)	1525-1570, 1630-1665, 1785-1800

Nota Bene: There is something strange concerning the statistics for Westbroek 1 and 3. 1957/1958 is not provided by the program because apparently the probability is <68%, it is not within the 1-sigma values (but this dating possibility is within 2-sigma). Anyhow it is evident that these years are part of the result because the red curve (the dating) intersects the calibration curve.

## 7. Discussion

The numbering Stobbenribben 1-2 follows the sample sequence from top to bottom, ST1 (20 cm) being more recent than ST2 (35 cm). This allows us to exclude the date interval 1957-1958 for ST1, meaning ST1 corresponds to the date interval 1993-1996. According to Bergmans (1975) vegetation survey of Stobbenribben, in 1973 *Typha angustifolia* was well established at the sample location. This does not exclude the 1972-1974 interval for ST2 but because the species was already well established, it makes it most probable that ST2 corresponds to 1962-1963.

The numbering Westbroek 1-5 follows the sample sequence from top to bottom. When we combine the knowledge about the vegetation development of the site (based on field observations in the past) and the recorded sequence based on microfossils and macroremains we can exclude some of the dating intervals as given above.

Westbroek radiocarbon samples 1, 2, 3, 4 and 5 respectively correspond to depths 10 cm, 18 cm, 23 cm, 27 cm and 33 cm. The Westbroek core sample was taken on a plot where *Calliergonella cuspidata* was dominating in 1988. According to the paleoecological diagram of the local vegetation succession in Westbroekse Zodden, *C. cuspidata* roughly comes in at depth 15 cm and disappears again roughly at depth 9 cm. 1988 must then roughly be situated between depths 9 cm and 15 cm. Westbroek sample 2 (18 cm depth) and Westbroek sample 3 (23 cm depth) have the option of being situated around 1988 but sample 2 is closest to the 9-15 cm interval for the occurrence of *C. cuspidata*. Moreover, keeping in mind that chronologically Westbroek 2 must come after Westbroek 3, 1989-1991 can be excluded for Westbroek 3 and 1958 can be excluded for Westbroek 2. For Westbroek 1, the only possible option with the sequence is 2005-2008. Based on stratigraphical positions, Westbroek 4 being younger than Westbroek 5, we can exclude some of the time intervals of the probability distribution in calendar ages. Thus Westbroek 4 is situated around 1575-1625 and Westbroek 5 around 1525-1570.

#### 8. Summary of the final dating results:

Name	Location	Depth (cm)	Material	Lab number	<sup>14</sup> a (%)	<sup>14</sup> C age (BP)	Calibrated (final) ages
ST1	Stobbenribben	20	above-ground material (seeds, etc.)	GrA-61962	112.45 ± 0.37	--	1993-1996
ST2	Stobbenribben	35		GrA-61965	143.97 ± 0.42	--	1962-1963
WB1	Westbroek	10		GrA-60711	106.09 ± 0.42	--	2005-2008
WB2	Westbroek	18		GrA-60712	117.13 ± 0.46	--	1988-1989
WB3	Westbroek	23		GrA-60713	115.59 ± 0.45	--	1958
WB4	Westbroek	27		GrA-60715	95.57 ± 0.39	364 ± 33	1575-1625
WB5	Westbroek	33		GrA-60718	96.69 ± 0.40	270 ± 33	1525-1570