Vedlegg 5

^{137}Cs aktivitet i sediment og ^{210}Pb datering av kjernar i Mareano-prosjektet. ^{210}Pb og ^{137}Cs analyserapport. Leverandør av data: Gamma Dating Center (GDC), Københavns Universitet, 8 sedimentkjerner.

Gamma Dating Center Copenhagen

Copenhagen, July 1st, 2014

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Dating of core R1114MC003kA

Dating of core R1114MC003kA

Methods

The samples have been analysed for the activity of ^{210}Pb, ^{226}Ra and ^{137}Cs via gammaspectrometry at the Gamma Dating Center, Institute of Geography, University of Copenhagen. The measurements were carried out on a Canberra ultralow-background Ge-well-detector. ^{210}Pb was measured via its gamma-peak at 46,5 keV, ^{226}Ra via the granddaughter ^{214}Pb (peaks at 295 and 352 keV) and ^{137}Cs via its peak at 661 keV.

Results

The core showed surface contents of unsupported ^{210}Pb of around 350 Bq kg-1 with a clear tenndency for exponential decline with depth except for the upper two cm which showed uniform activity (fig 1). The calculated flux of unsupported ^{210}Pb is 382 which is about twice the estimated atmospheric supply to the site (based on data in Appleby, 2001). This shows that the site is subject to sedimentation.

The content of ^{137}Cs was generally very low and below detection limit at depths deeper than 6 cm.

CRS-modelling has been applied on the profile using a modified method (Appleby, 2001) where the activity below 7 cm is calculated on the basis of the regression shown in fig 2. The result is given in table 2 and fig 3 and 4.

The chronology given in table 2 is only valid if bioturbation and other sediment mixing is negligible. If this is not the case, ages given in table 2 are underestimated and accumulation rates are overestimated. The uniform activity of unsupported ^{210}Pb in the very top of the core indicates that shallow mixing does take place at the site but the data suggests that the mixing is indeed very shallow and confined to the upper 2 cm. The chronology is therefore believed to be reasonably reliable except for the upper 2 cm.

Copenhagen, July 1st, 2014

Thorbjørn J Andersen

Reference:

Appleby, P.G. (2001): Chronostratigraphic techniques in recent sediments. In: Last, W.M & Smol, J.P. (eds) Tracking environmental change using lake sediments. Volume 1: Basin analysis, coring and chronological techniques. Kluwer Academic Publishers, the Netherlands.

Table 1. Raw data, R1114MC003kA

Depth cm	Pb-210tot Bq kg-1	error Pb-210 tot Bq kg-1	Pb-210 sup Bq kg-1	error Pb-210 sup Bq kg-1	Pb-210 unsup Bq kg-1	error Pb-210 unsup Bq kg-1	Cs-137 Bq kg-1	error Cs-137 Bq kg-1
0.5	379	28	14	3	365	29	0	0
1.5	374	41	25	8	350	41	0	0
2.5	295	29	18	2	277	29	3	1
3.5	183	19	23	3	160	19	2	1
4.5	119	12	22	1	97	12	0	0
5.5	93	13	25	2	68	13	1	1
6.5	37	5	17	0	20	5	0	0
7.5	22	4	20	4	2	6	0	0
8.5	39	6	17	1	23	6	0	0
9.5	12	3	17	1	0	3	0	0
22.5	19	2	19	1	0	2	0	0

Table 2, Chronology core R1114MC003kA

Depth cm	Age (y)	error age (y)	Date (y)	acc rate (kg m-2 y-1)	error rate (kg m-2 y-1)	Date acc rate (y)
			2013			
0.5	4	2	2009	0.98	0.09	2011
1.5	15	2	1998	0.79	0.10	2003
2.5	30	3	1983	0.61	0.07	1990
3.5	48	3	1965	0.52	0.07	1974
4.5	67	4	1946	0.50	0.08	1955
5.5	91	7	1922	0.41	0.10	1934
6.5	123	9	1890	0.32	0.09	1906

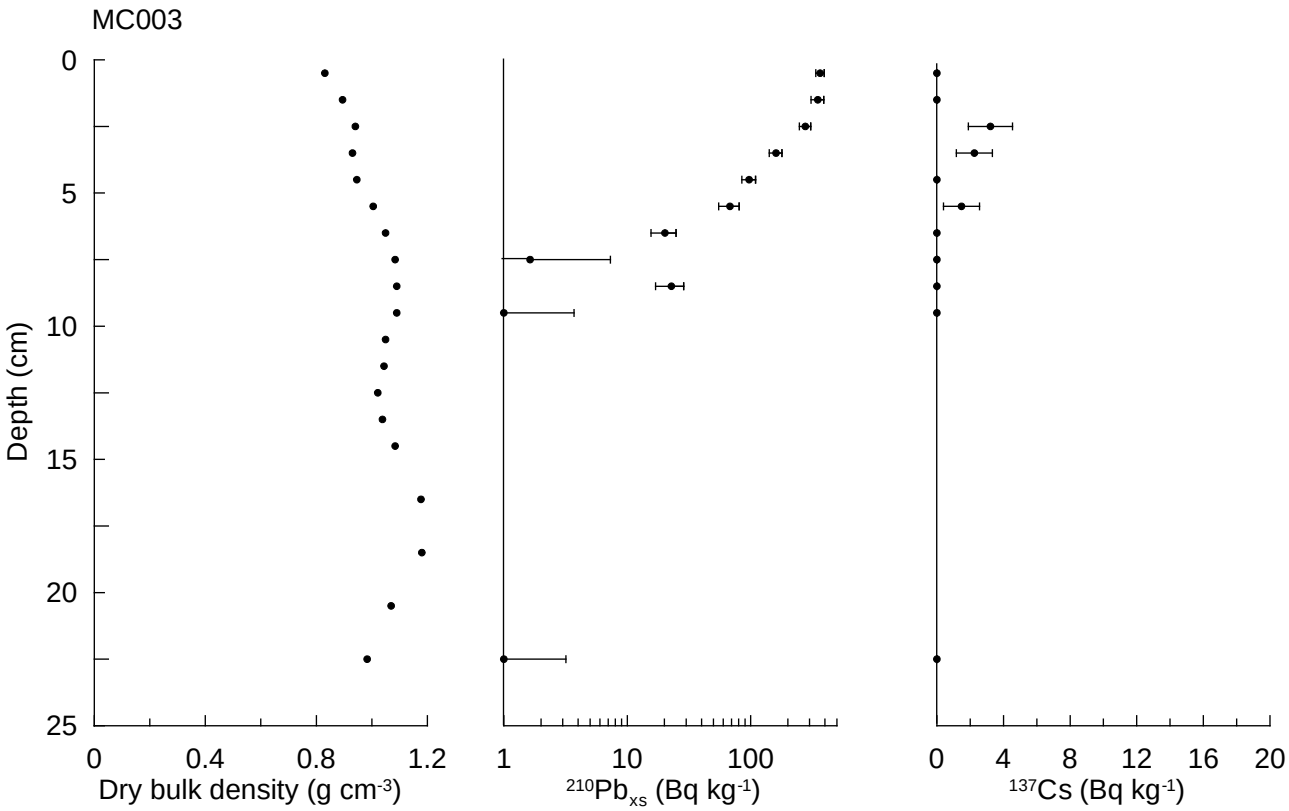

Fig 1

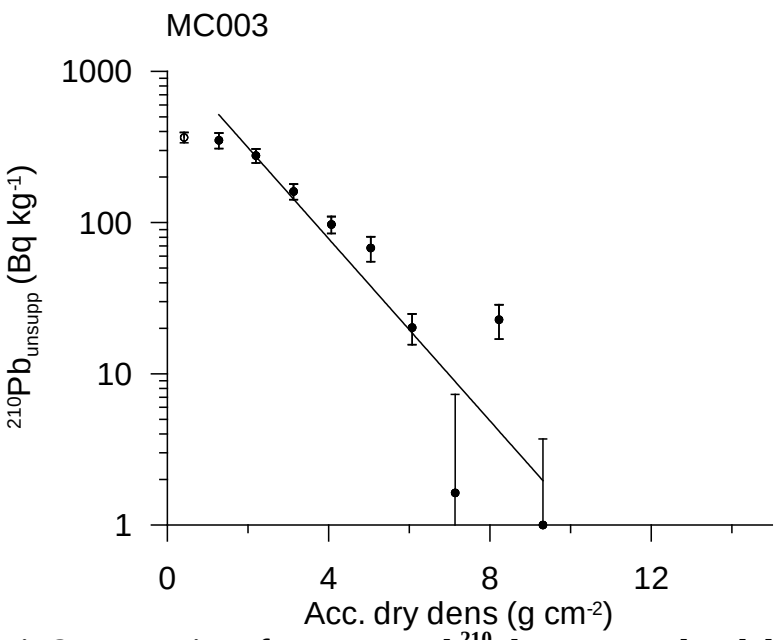

Fig 2. Regression of unsupported ^{210}Pb vs accumulated dry density. Solid circles are included in the analysis, open circles are not.

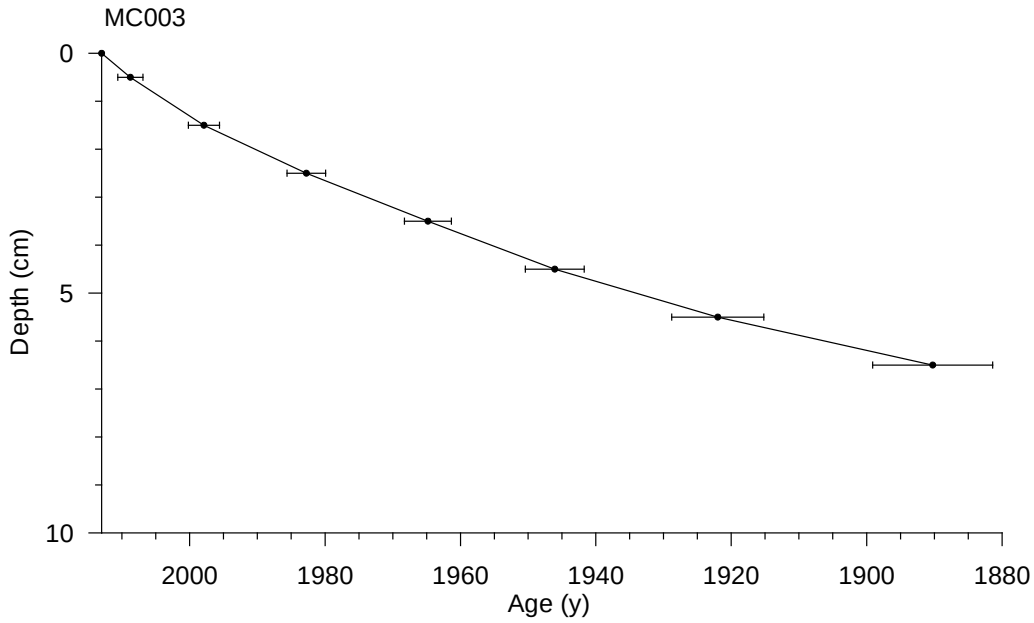
MC003
0
5
10
Depth (cm)
2000
1980
1960
1940
1920
1900
1880
Age (y)

Fig 3

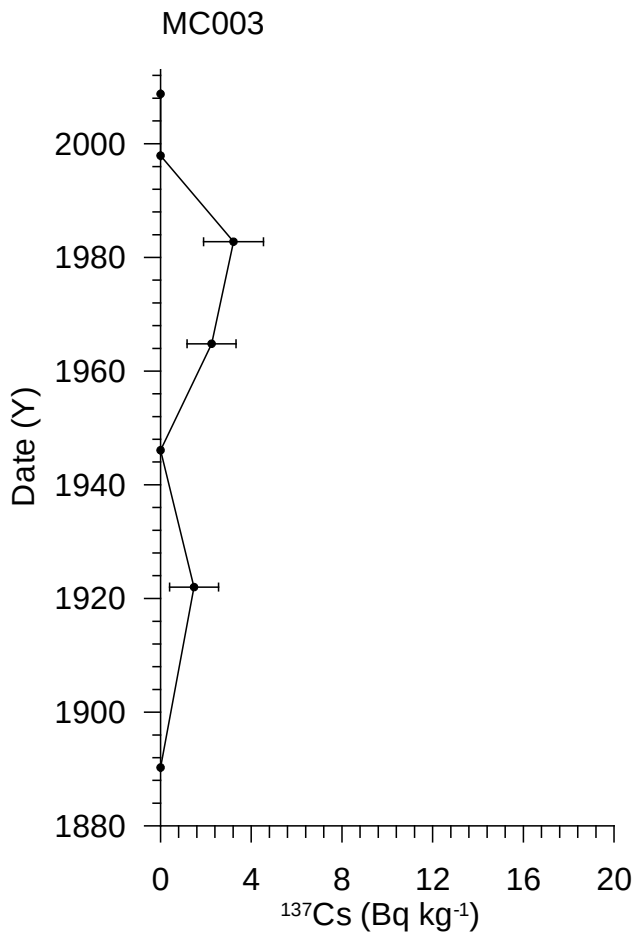
MC003
2000
1980
1960
1940
1920
1900
1880
Date (Y)
0
4
8
12
16
20
137Cs (Bq kg-1)

Fig 4

Gamma Dating Center Copenhagen

Copenhagen, 25 June 2014

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Dating of core R0942BX026K1

Dating of core R0942BX026K1

Methods

The samples have been analysed for the activity of ^{210}Pb, ^{226}Ra and ^{137}Cs via gammaspectrometry at the Gamma Dating Center, Institute of Geography, University of Copenhagen. The measurements were carried out on a Canberra ultralow-background Ge-detector. ^{210}Pb was measured via its gamma-peak at 46,5 keV, ^{226}Ra via the granddaughter ^{214}Pb (peaks at 295 and 352 keV) and ^{137}Cs via its peak at 661 keV.

Results

The core showed surface contents of unsupported ^{210}Pb of around 760 Bq kg-1 with a clear tendency for exponential decline with depth except for the top three samples which showed uniform activity (fig 1). The calculated flux of unsupported ^{210}Pb is 455 Bq m^{-2} y^{-1}.

The content of ^{137}Cs was generally low and below detection limit at depths deeper than 10 cm. A minor peak is centered around 2.5 cm depth.

CRS-modelling has been applied on the profile using a modified method (Appleby, 2001) where the activity below 6.5 cm is calculated on the basis of the regression shown in fig 2. The result is given in table 2 and fig 3 and 4.

The chronology given in table 2 is only valid if bioturbation and other sediment mixing is negligible. If this is not the case, ages given in table 2 are underestimated and accumulation rates are overestimated. The uniform activity of unsupported ^{210}Pb in the top of the core indicates that shallow mixing does take place at the site and it is in fact possible that the entire profile is dominated by sediment mixing. However, the mixing does not appear to be severe and the chronology is therefore considered to be reasonably reliable.

Copenhagen, 25 June 2014

Thorbjørn J Andersen

Reference:

Appleby, P.G. (2001): Chronostratigraphic techniques in recent sediments. In: Last, W.M & Smol, J.P. (eds) Tracking environmental change using lake sediments. Volume 1: Basin analysis, coring and chronological techniques. Kluwer Academic Publishers, the Netherlands.

Table 1. Raw data, R0942BX026K1

Depth cm	Pb-210tot Bq kg-1	error Pb-210 tot Bq kg-1	Pb-210 sup Bq kg-1	error Pb-210 sup Bq kg-1	Pb-210 unsup Bq kg-1	error Pb-210 unsup Bq kg-1	Cs-137 Bq kg-1	error Cs-137 Bq kg-1
0.5	794	53	29	3	765	53	4	2
1.5	794	84	28	1	765	84	0	0
2.5	778	70	37	10	741	71	9	3
3.5	373	24	33	1	341	24	3	1
4.5	205	25	30	3	176	25	2	2
6.5	69	9	37	1	32	9	0	0
7.5	52	7	32	1	20	7	0	0
8.5	40	4	34	0	7	4	0	0
9.5	40	6	36	1	4	6	0	0
10.5	57	7	38	1	19	7	1	1
12.5	41	7	38	6	3	9	0	0

Table 2, Chronology core R0942BX026K1

Depth cm	Age y	error age y	Date y	acc rate (kg m-2 y-1)	error rate (kg m-2 y-1)	Date acc rate y
			2013			
0.5	4	2	2009	0.56	0.04	2011
1.5	13	2	2000	0.46	0.05	2004
2.5	29	3	1984	0.32	0.03	1992
3.5	50	3	1963	0.25	0.03	1974
4.5	72	4	1941	0.27	0.04	1952
6.5	124	13	1889	0.23	0.11	1915

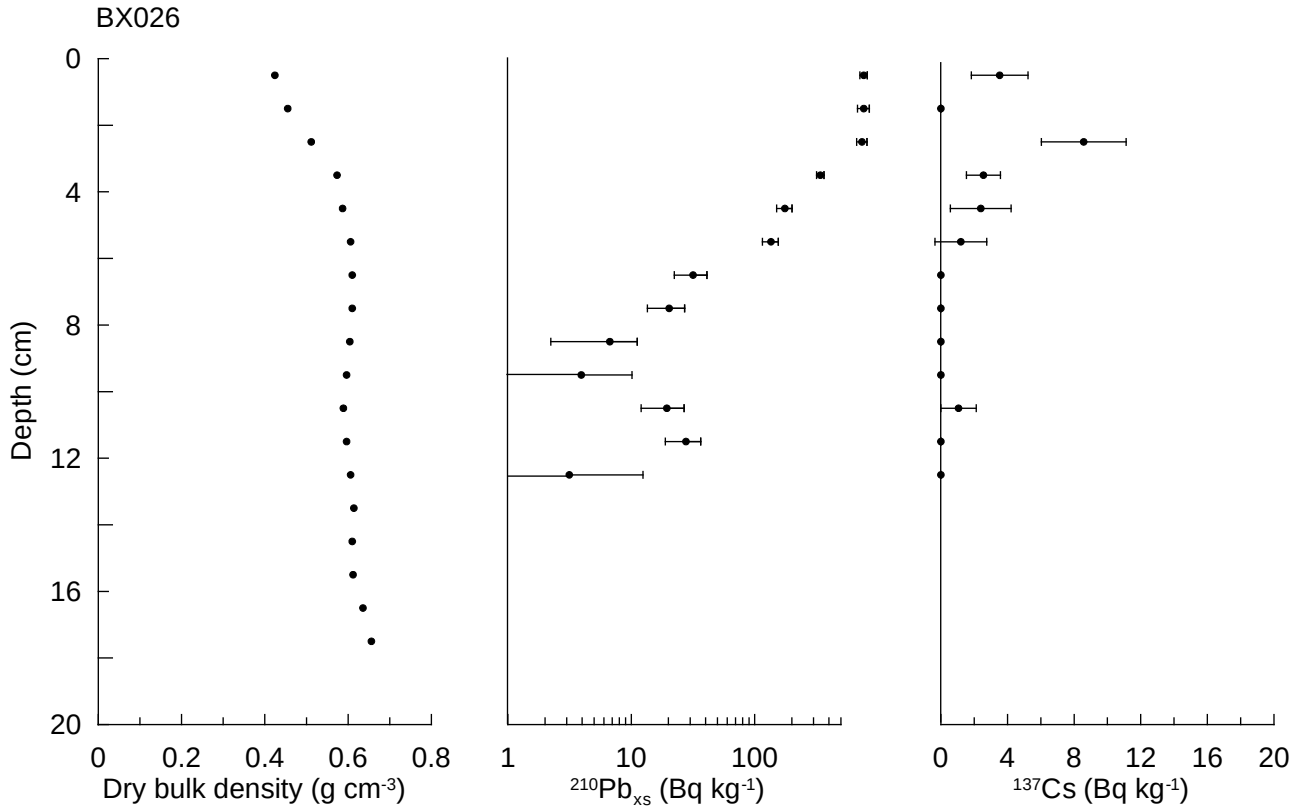

Fig 1

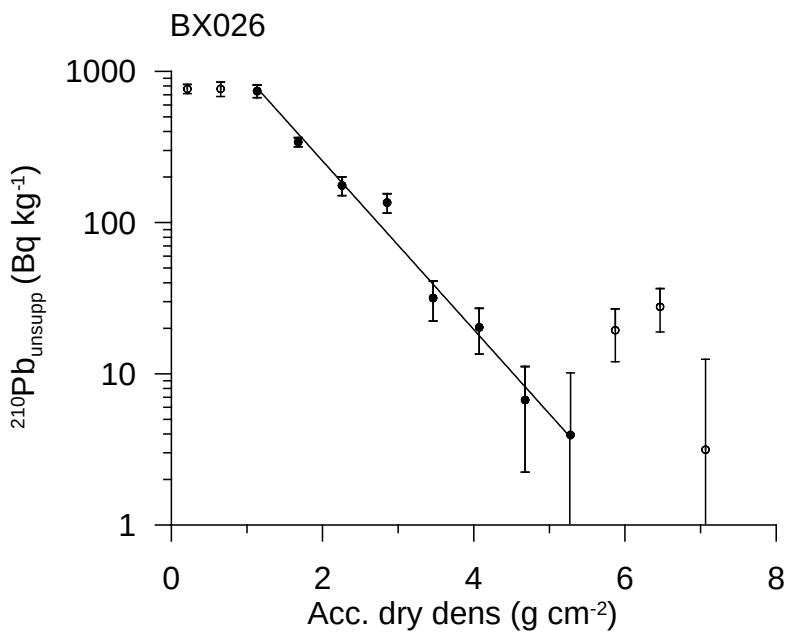

Fig 2. Regression of unsupported ^{210}Pb vs accumulated dry density. Solid circles are included in the analysis, open circles are not.

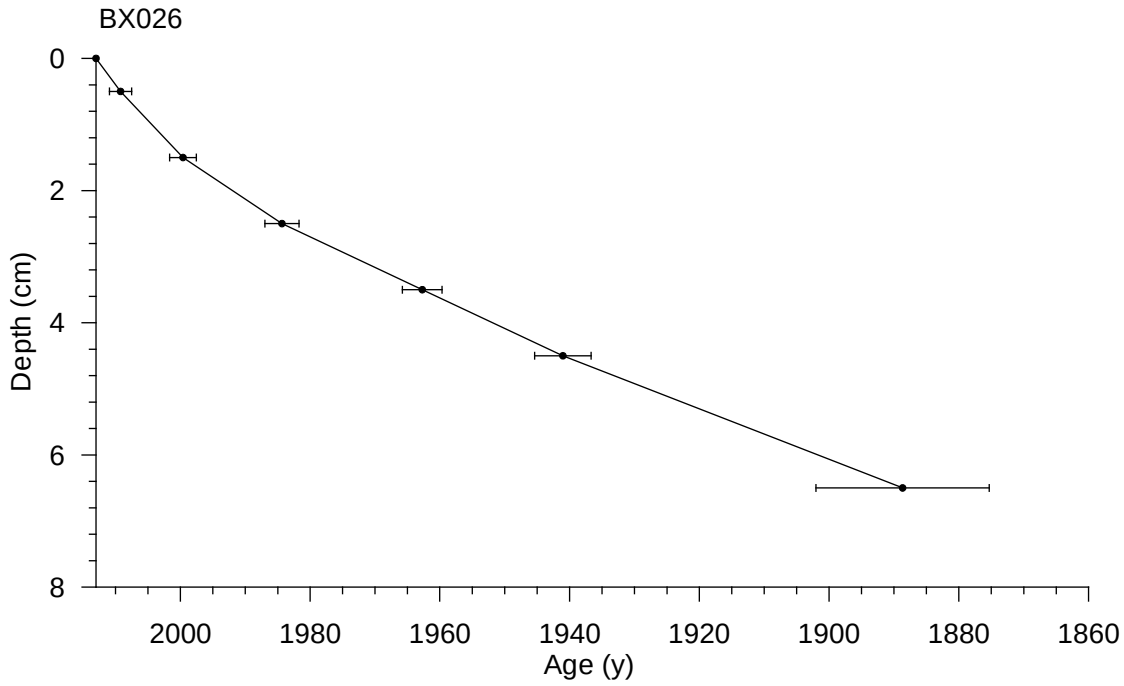
BX026
0
2
4
6
8
Depth (cm)
2000
1980
1960
1940
1920
1900
1880
1860
Age (y)

Fig 3

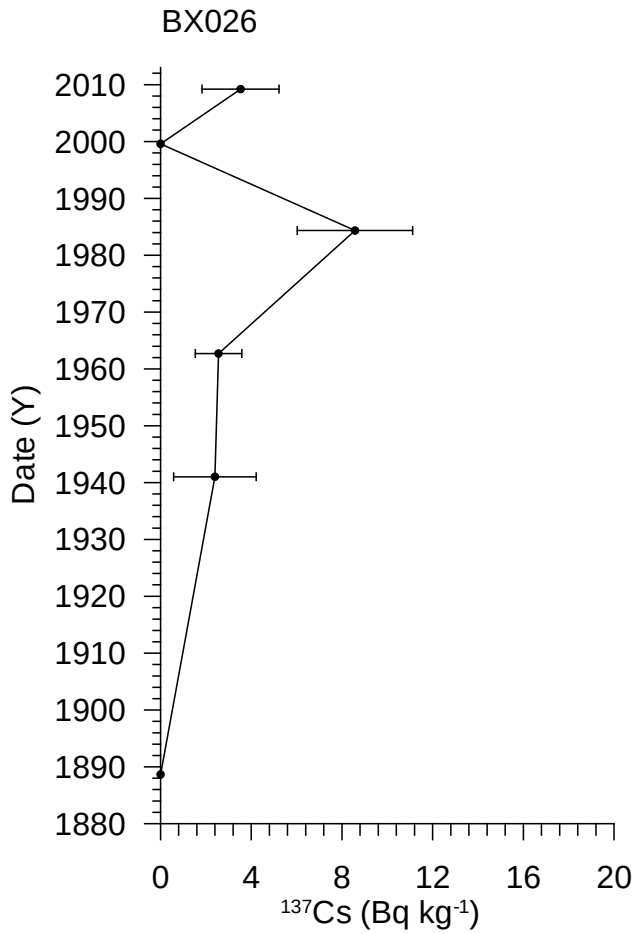
BX026
2010
2000
1990
1980
1970
1960
1950
1940
1930
1920
1910
1900
1890
1880
Date (Y)
0
4
8
12
16
20
137Cs (Bq kg-1)

Fig 4

Gamma Dating Center Copenhagen

Copenhagen, July 1st, 2014

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Dating of core R949MC028KA

Dating of core R949MC028KA

Methods

The samples have been analysed for the activity of ^{210}Pb, ^{226}Ra and ^{137}Cs via gammaspectrometry at the Gamma Dating Center, Institute of Geography, University of Copenhagen. The measurements were carried out on a Canberra ultralow-background Ge-detector. ^{210}Pb was measured via its gamma-peak at 46,5 keV, ^{226}Ra via the granddaughter ^{214}Pb (peaks at 295 and 352 keV) and ^{137}Cs via its peak at 661 keV.

Results

The core showed surface contents of unsupported ^{210}Pb of around 340 Bq kg-1 with a clear tenndency for exponential decline with depth in the upper 8 cm except for the upper two cm which showed uniform activity (fig 1). The activities are low and irregular below 8 cm depth. The calculated flux of unsupported ^{210}Pb is 300 which is about twice the estimated atmospheric supply to the site (based on data in Appleby, 2001). This shows that the site is subject to sedimentation.

The content of ^{137}Cs was generally very low and below detection limit at depths deeper than 11 cm.

CRS-modelling has been applied on the profile using a modified method (Appleby, 2001) where the activity below 8 cm is calculated on the basis of the regression shown in fig 2. One outlier in the profile, 5.5 cm depth, was assigned an activity based on the same regression. The result is given in table 2 and fig 3 and 4.

The chronology given in table 2 is only valid if bioturbation and other sediment mixing is negligible. If this is not the case, ages given in table 2 are underestimated and accumulation rates are overestimated. The uniform activity of unsupported ^{210}Pb in the very top of the core indicates that shallow mixing does take place at the site. This is also supported by fig 4 which shows ^{137}Cs in layers dated to before the first significant releases into nature (around 1960). Based on these observations it is possible that profiles of unsupported ^{210}Pb and ^{137}Cs are dominated by sediment mixing and the chronology given in table 2 is therefore only indicative.

Copenhagen, July 1st, 2014

Thorbjørn J Andersen

Reference:

Appleby, P.G. (2001): Chronostratigraphic techniques in recent sediments. In: Last, W.M & Smol, J.P. (eds) Tracking environmental change using lake sediments. Volume 1: Basin analysis, coring and chronological techniques. Kluwer Academic Publishers, the Netherlands.

Table 1. Raw data, R949MC028KA

Depth cm	Pb-210tot Bq kg-1	error Pb-210 tot Bq kg-1	Pb-210 sup Bq kg-1	error Pb-210 sup Bq kg-1	Pb-210 unsup Bq kg-1	error Pb-210 unsup Bq kg-1	Cs-137 Bq kg-1	error Cs-137 Bq kg-1
0.5	365	29	18	1	346	29	5	2
1.5	353	27	27	5	327	27	8	2
2.5	225	24	25	2	200	24	8	3
3.5	174	12	24	6	150	14	4	1
4.5	109	9	24	2	85	10	5	1
5.5	192	13	28	1	164	13	2	1
6.5	70	6	24	2	46	7	3	1
7.5	37	4	24	2	13	5	4	1
8.5	46	5	22	0	24	5	3	2
10.5	46	6	18	1	28	6	4	2
12.5	43	4	29	2	14	4	1	1
16.5	40	5	22	3	18	6	0	0
20.5	32	4	23	2	9	4	0	0
30.5	38	3	30	1	8	4	0	1

Table 2, Chronology core R949MC028KA

Depth cm	Age (y)	error age (y)	Date (y)	acc rate (kg m-2 y-1)	error rate (kg m-2 y-1)	Date acc rate (y)
			2013			
0.5	4	2	2009	0.82	0.07	2011
1.5	14	2	1999	0.68	0.06	2004
2.5	26	2	1987	0.62	0.08	1993
3.5	39	3	1974	0.63	0.07	1981
4.5	52	3	1961	0.62	0.09	1967
5.5	66	4	1947	0.65	0.14	1954
6.5	81	5	1932	0.57	0.12	1940
7.5	94	7	1919	0.68	0.15	1926

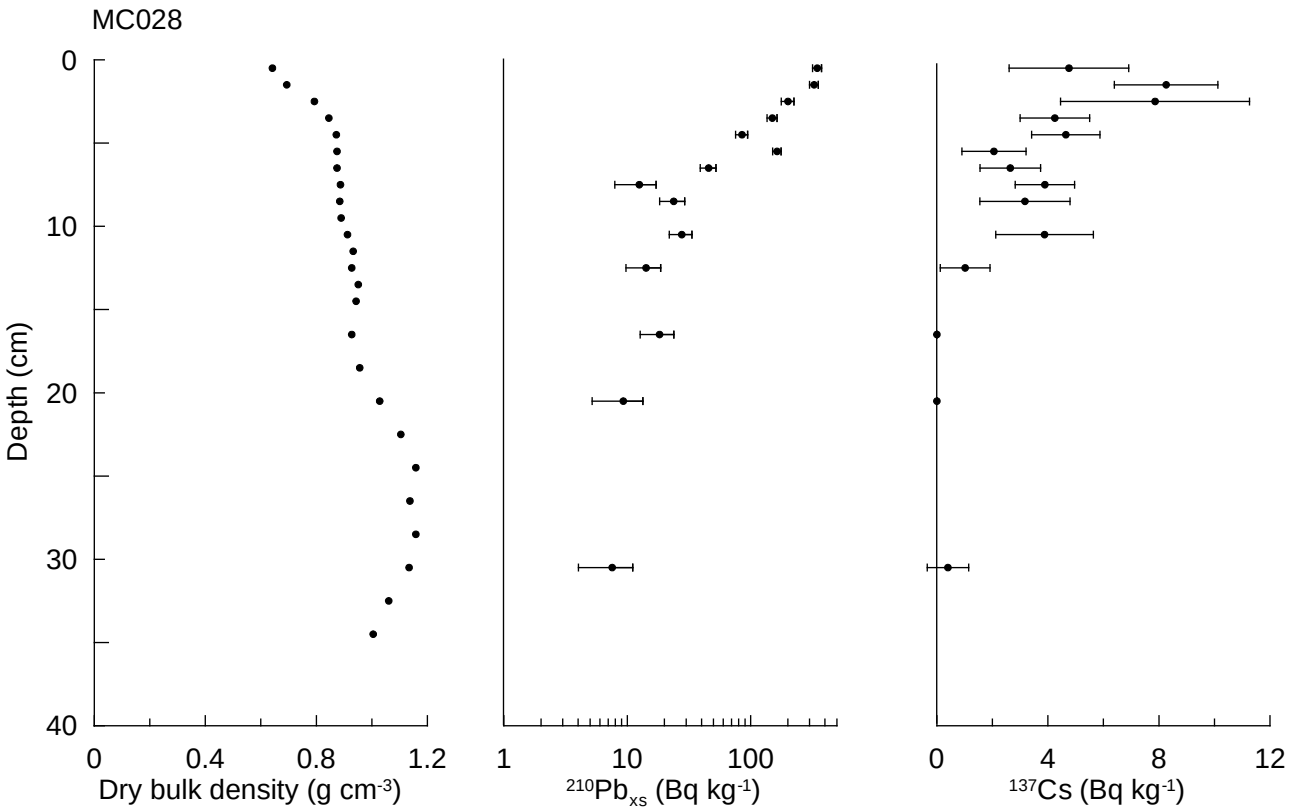

Fig 1

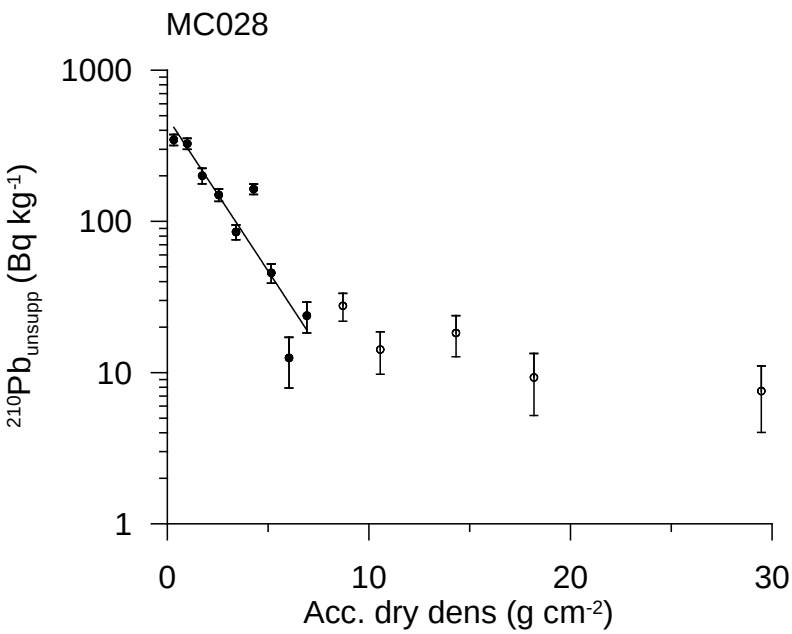

Fig 2. Regression of unsupported ^{210}Pb vs accumulated dry density. Solid circles are included in the analysis, open circles are not.

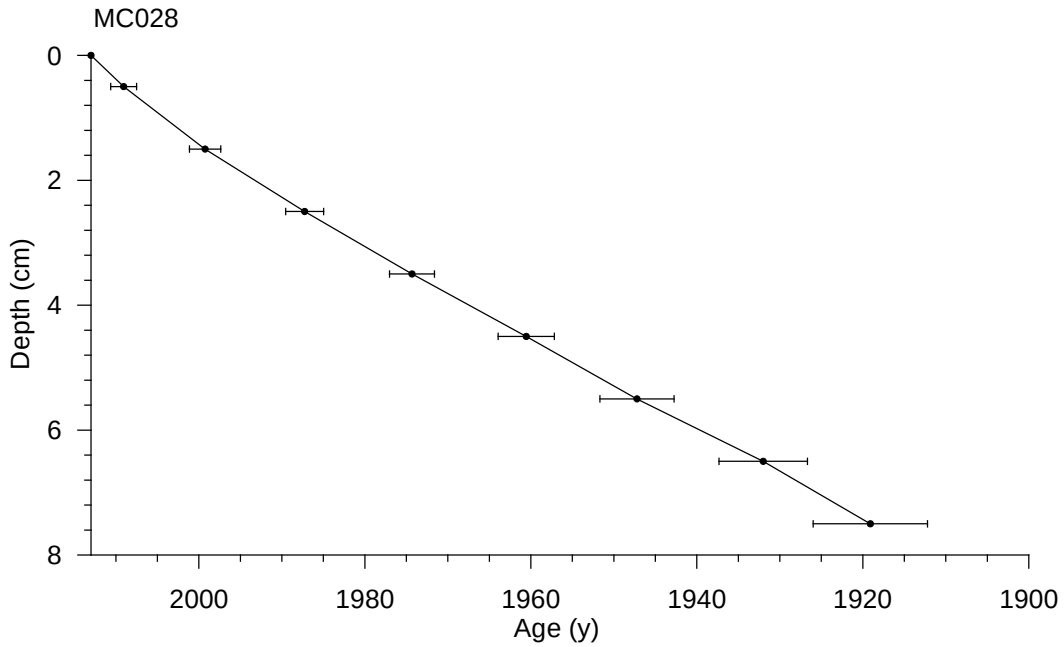
MC028
Depth (cm)
0
2
4
6
8
2000
1980
1960
1940
1920
1900
Age (y)

Fig 3

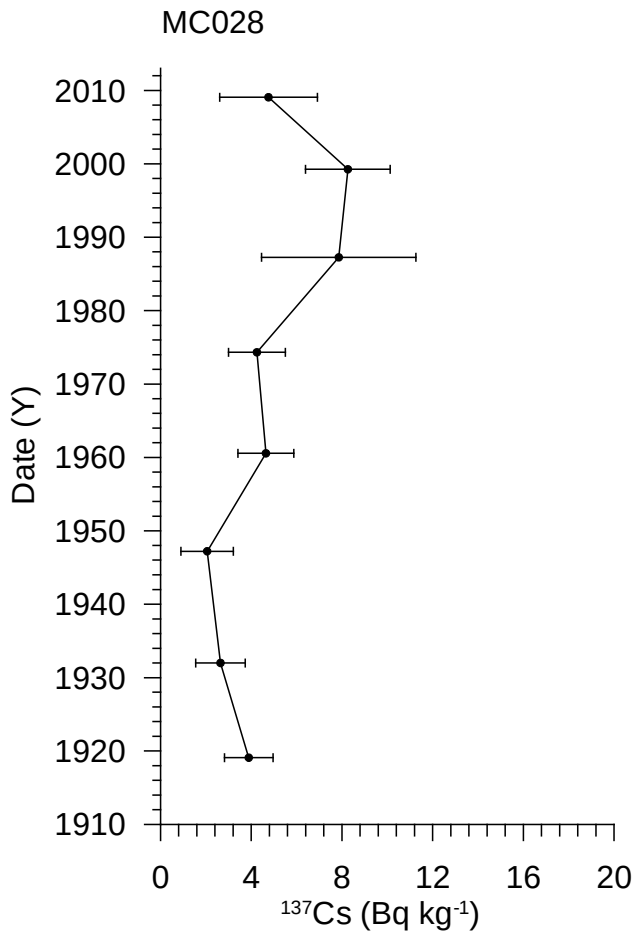
MC028
Date (Y)
2010
2000
1990
1980
1970
1960
1950
1940
1930
1920
1910
0
4
8
12
16
20
137Cs (Bq kg-1)

Fig 4

Gamma Dating Center Copenhagen

Copenhagen, July 14th, 2014

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Dating of core R889MC025KA

Dating of core R889MC025KA

Methods

The samples have been analysed for the activity of ^{210}Pb, ^{226}Ra and ^{137}Cs via gammaspectrometry at the Gamma Dating Center, Institute of Geography, University of Copenhagen. The measurements were carried out on a Canberra ultralow-background Ge-detector. ^{210}Pb was measured via its gamma-peak at 46,5 keV, ^{226}Ra via the granddaughter ^{214}Pb (peaks at 295 and 352 keV) and ^{137}Cs via its peak at 661 keV.

Results

The core showed surface contents of unsupported ^{210}Pb of around 350 Bq kg-1 with a clear tendency for exponential decline with depth in the upper 11 cm (fig 1). Below this depth the activity was below detection limits. The calculated flux of unsupported ^{210}Pb is about 700 Bq m^{-2} y^{-1}, which is about an order of magnitude higher that the estimated atmospheric supply to the site (based on data in Appleby, 2001). This shows that the site is subject to intense sedimentation.

The content of ^{137}Cs was generally very low and below detection limit at depths deeper than 11 cm.

CRS-modelling has been applied on the profile using a modified method (Appleby, 2001) where the activity below 11 cm is calculated on the basis of the regression shown in fig 2. The result is given in table 2 and fig 3 and 4.

The chronology given in table 2 is only valid if bioturbation and other sediment mixing is negligible. If this is not the case, ages given in table 2 are underestimated and accumulation rates are overestimated. The clear tendency for exponential decline in the activity and the high inventory of unsupported ^{210}Pb suggests that the chronology is reliable and that the site has been subject to intense sedimentation after around 1963. Layers below 11 cm depth are deposited at least 100 years ago. Alternatively, the site is subject to sediment slumping but without any slumping since 1963.

Copenhagen, July 14th, 2014

Thorbjørn J Andersen

Reference:

Appleby, P.G. (2001): Chronostratigraphic techniques in recent sediments. In: Last, W.M & Smol, J.P. (eds) Tracking environmental change using lake sediments. Volume 1: Basin analysis, coring and chronological techniques. Kluwer Academic Publishers, the Netherlands.

Table 1. Raw data, R889MC025KA

Depth cm	Pb-210tot Bq kg-1	error Pb-210 tot Bq kg-1	Pb-210 sup Bq kg-1	error Pb-210 sup Bq kg-1	Pb-210 unsup Bq kg-1	error Pb-210 unsup Bq kg-1	Cs-137 Bq kg-1	error Cs-137 Bq kg-1
0.5	368	15	18	8	350	23	1	1
1.5	341	26	19	5	322	31	5	2
2.5	293	24	24	6	269	30	5	2
3.5	236	18	14	1	222	19	4	2
4.5	213	22	24	5	189	27	4	2
5.5	193	21	29	8	164	29	3	2
6.5	176	16	22	2	155	18	1	2
7.5	166	8	23	3	143	11	3	1
8.5	135	14	22	9	113	22	2	2
9.5	103	12	16	7	87	19	2	2
10.5	100	13	21	1	79	14	0	0
11.5	20	4	20	0	0	5	0	0
13.5	19	4	24	5	0	9	0	0
14.5	19	4	25	2	0	7	0	0
20.5	35	8	22	0	13	8	3	2

Table 2, Chronology core R889MC025KA

Depth cm	Age y	error age y	Date y	acc rate (kg m-2 y-1)	error rate (kg m-2 y-1)	Date acc rate y
			2013			
0.5	2	2	2011	1.93	0.16	2012
1.5	6	2	2007	1.85	0.20	2009
2.5	10	2	2003	1.85	0.23	2005
3.5	14	2	1999	1.93	0.22	2001
4.5	19	3	1994	2.01	0.32	1996
5.5	24	3	1989	2.02	0.39	1992
6.5	29	3	1984	1.93	0.30	1987
7.5	34	4	1979	1.76	0.26	1982
8.5	39	4	1974	1.73	0.41	1976
9.5	45	5	1968	1.88	0.51	1971
10.5	50	6	1963	1.91	0.39	1966
11.5	> 100					

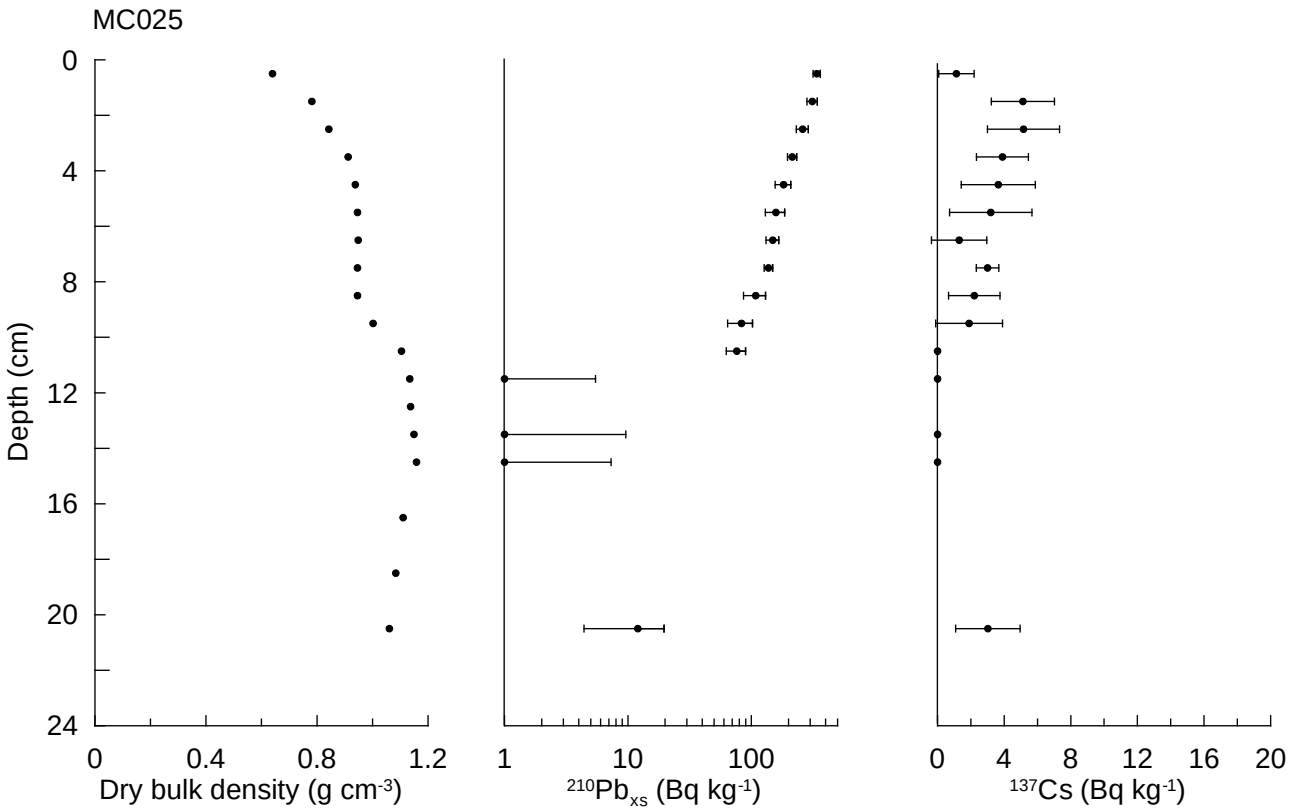

Fig 1

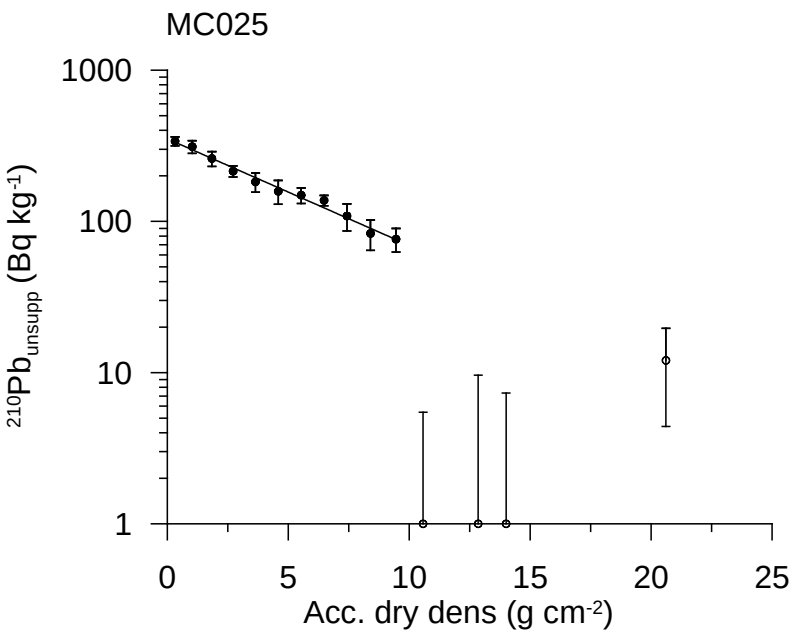

Fig 2. Regression of unsupported ^{210}Pb vs accumulated dry density. Solid circles are included in the analysis, open circles are not.

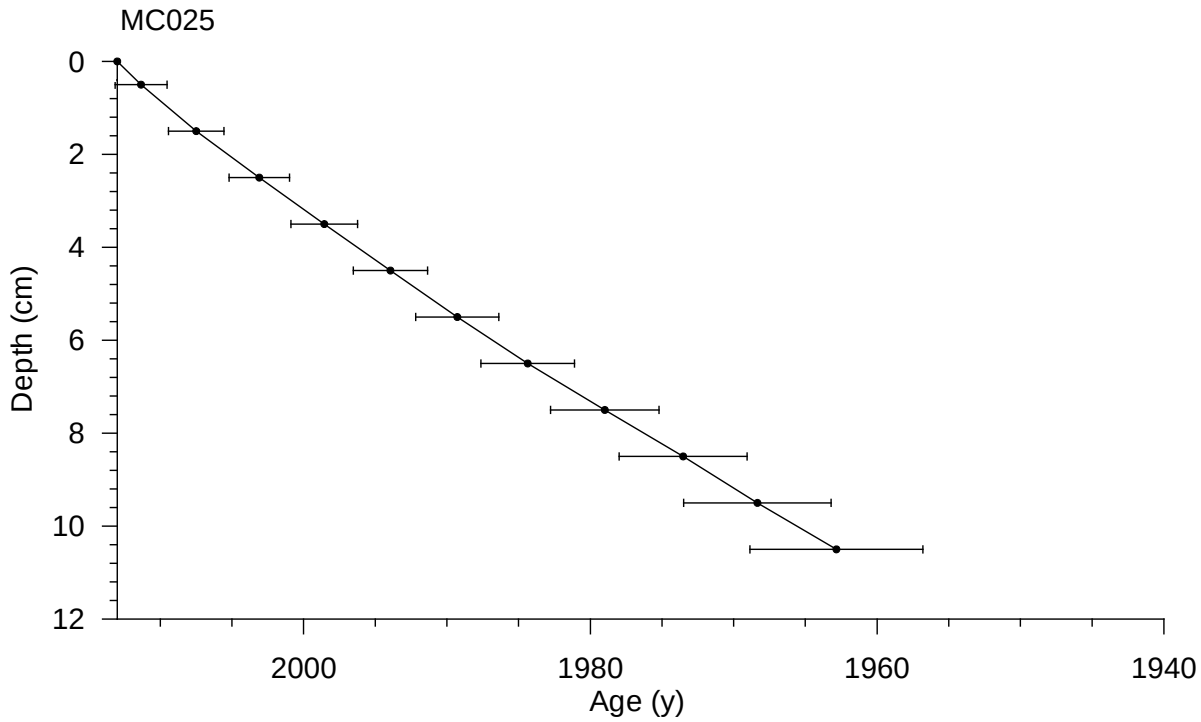
MC025
Depth (cm)
0
2
4
6
8
10
12
2000
1980
1960
1940
Age (y)

Fig 3

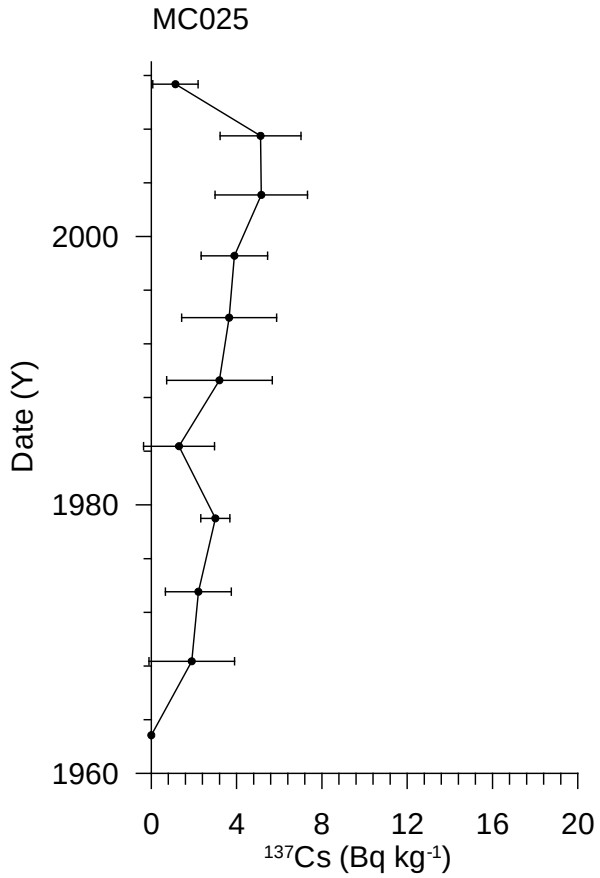
MC025
Date (Y)
2000
1980
1960
0
4
8
12
16
20
137Cs (Bq kg-1)

Fig 4

Gamma Dating Center Copenhagen

Copenhagen, July 1st, 2014

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fax +45 35 32 25 01

Dating of core R1261MC020KA

Dating of core R1261MC020KA

Methods

The samples have been analysed for the activity of ^{210}Pb, ^{226}Ra and ^{137}Cs via gammaspectrometry at the Gamma Dating Center, Institute of Geography, University of Copenhagen. The measurements were carried out on a Canberra ultralow-background Ge-detector. ^{210}Pb was measured via its gamma-peak at 46,5 keV, ^{226}Ra via the granddaughter ^{214}Pb (peaks at 295 and 352 keV) and ^{137}Cs via its peak at 661 keV.

Results

The core showed surface contents of unsupported ^{210}Pb of around 600 Bq kg-1 with fairly uniform activity in the upper 8 cm and a clear tendency for exponential decline with depth below that level (fig 1). The calculated flux of unsupported ^{210}Pb is very high, 1500 Bq m^{-2} y^{-1}, which is more than a magnitude higher than the atmospheric supply to the site (based on data in Appleby, 2001). This shows that the site is subject to intense sedimentation.

The content of ^{137}Cs was generally low and below detection limit at depths deeper than 20 cm. A minor peak is centered around 9 cm depth.

CRS-modelling has been applied on the profile using a modified method (Appleby, 2001) where the activity below 30 cm is calculated on the basis of the regression shown in fig 2. The result is given in table 2 and fig 3 and 4.

The chronology given in table 2 is only valid if bioturbation and other sediment mixing is negligible. If this is not the case, ages given in table 2 are underestimated and accumulation rates are overestimated. The uniform activity of unsupported ^{210}Pb in the top of the core indicates that shallow mixing does take place at the site. This is also supported by fig 4 which shows ^{137}Cs in layers dated to before the first significant releases into nature (around 1960). However, fig 4 also shows a ^{137}Cs signal which is in reasonable accordance with the known contributions from the bomb test maximum in 1963 and the Chernobyl accident in 1986. The chronology is therefore believed to be reasonably reliable except for the upper 8 cm.

Copenhagen, July 1st, 2014

Thorbjørn J Andersen

Reference:

Appleby, P.G. (2001): Chronostratigraphic techniques in recent sediments. In: Last, W.M & Smol, J.P. (eds) Tracking environmental change using lake sediments. Volume 1: Basin analysis, coring and chronological techniques. Kluwer Academic Publishers, the Netherlands.

Table 1. Raw data, R1261MC020KA

Depth cm	Pb-210tot Bq kg-1	error Pb-210 tot Bq kg-1	Pb-210 sup Bq kg-1	error Pb-210 sup Bq kg-1	Pb-210 unsup Bq kg-1	error Pb-210 unsup Bq kg-1	Cs-137 Bq kg-1	error Cs-137 Bq kg-1
0.5	622	32	35	2	586	34	6	2
1.5	684	38	41	4	643	42	7	3
3.5	652	52	36	1	616	53	6	4
5.5	602	41	34	1	568	42	6	3
7.5	742	63	40	2	702	65	20	5
8.5	542	30	35	6	507	35	12	3
9.5	496	44	38	9	458	53	12	5
11.5	474	34	40	7	434	41	19	3
13.5	333	24	37	7	296	31	5	2
15.5	217	21	47	6	169	27	7	2
17.5	263	25	45	7	218	32	4	3
18.5	211	19	40	5	171	25	6	2
20.5	125	15	37	5	88	19	0	0
22.5	95	11	40	10	56	21	0	0
25.5	86	11	44	1	42	13	0	0
26.5	102	12	41	4	62	16	0	0
28.5	75	10	42	4	32	14	0	0
29.5	41	5	16	1	25	6	0	0
32.5	38	6	42	1	1	7	0	0
36.5	49	7	45	2	4	10	0	0

Table 2, Chronology core R1261MC020KA

Depth cm	Age (y)	error age (y)	Date (y)	Acc rate (kg m-2 y-1)	error rate (kg m-2 y-1)	Date acc rate (y)
			2013			
0.5	1	1	2012	2.53	0.17	2013
1.5	3	1	2010	2.31	0.16	2011
3.5	7	1	2006	2.03	0.18	2008
5.5	13	1	2000	1.85	0.15	2003
7.5	20	2	1993	1.41	0.14	1996
8.5	25	2	1988	1.23	0.10	1990
9.5	29	2	1984	1.36	0.15	1986
11.5	38	2	1975	1.20	0.13	1980
13.5	48	2	1965	1.09	0.13	1970
15.5	57	3	1956	1.26	0.20	1961
17.5	68	4	1945	1.11	0.19	1951
18.5	75	3	1938	0.84	0.13	1942
20.5	87	5	1926	0.95	0.22	1932
22.5	97	6	1916	1.20	0.42	1921
25.5	112	7	1901	1.21	0.42	1909
26.5	119	6	1894	0.80	0.21	1898
28.5	139	10	1874	0.58	0.28	1884
29.5	148	7	1865	0.59	0.13	1869

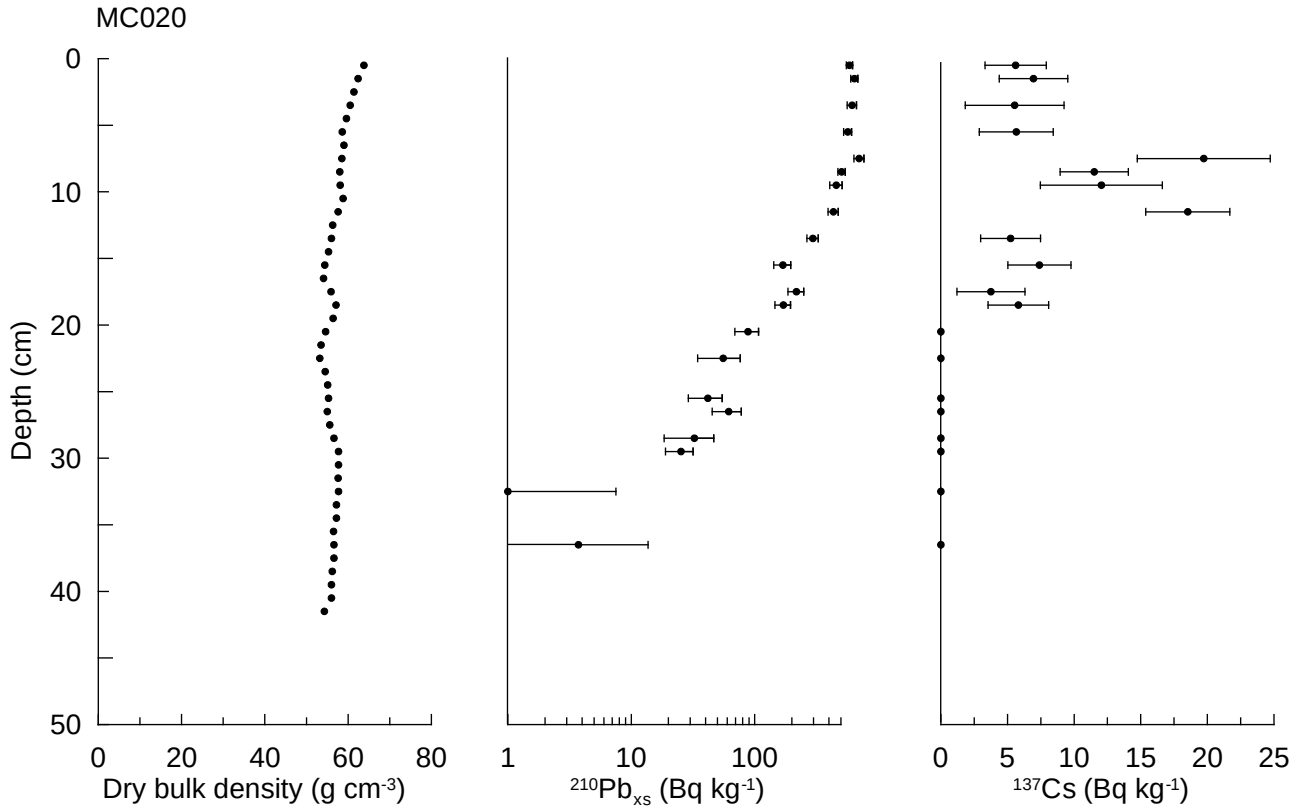

Fig 1

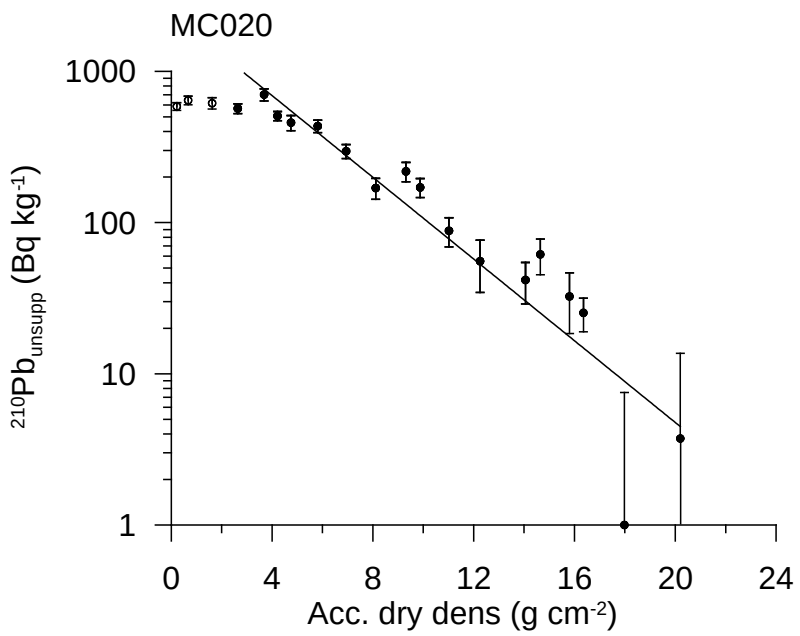

Fig 2. Regression of unsupported ^{210}Pb vs accumulated dry density. Solid circles are included in the analysis, open circles are not.

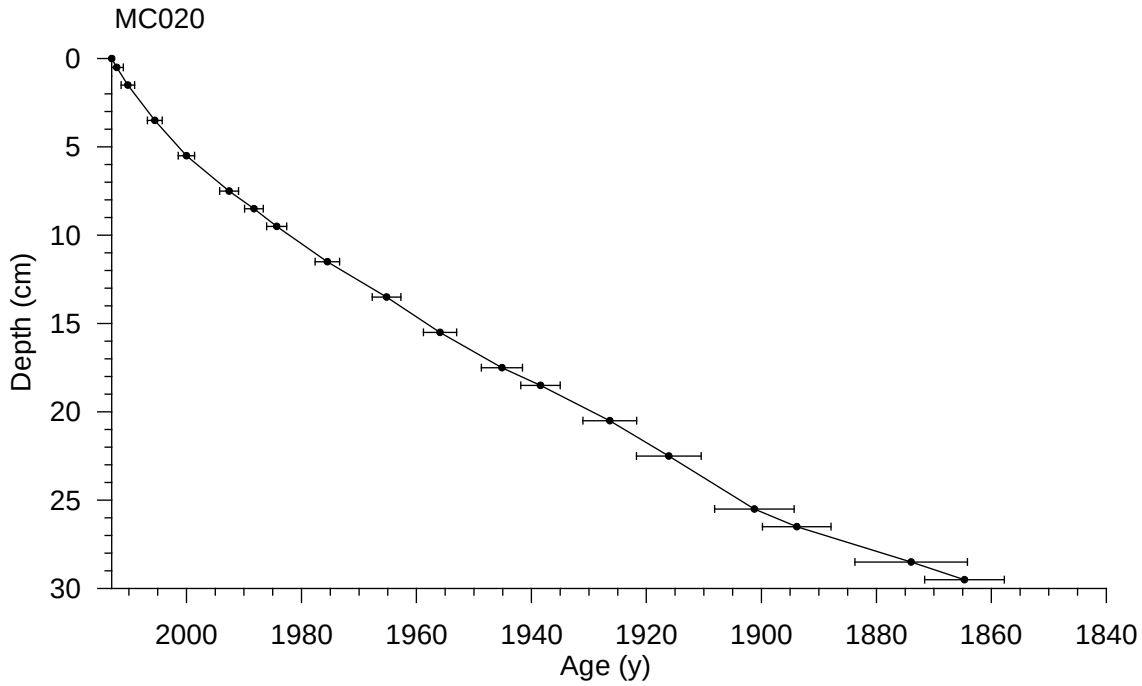
MC020
Depth (cm)
0
5
10
15
20
25
30
2000
1980
1960
1940
1920
1900
1880
1860
1840
Age (y)

Fig 3

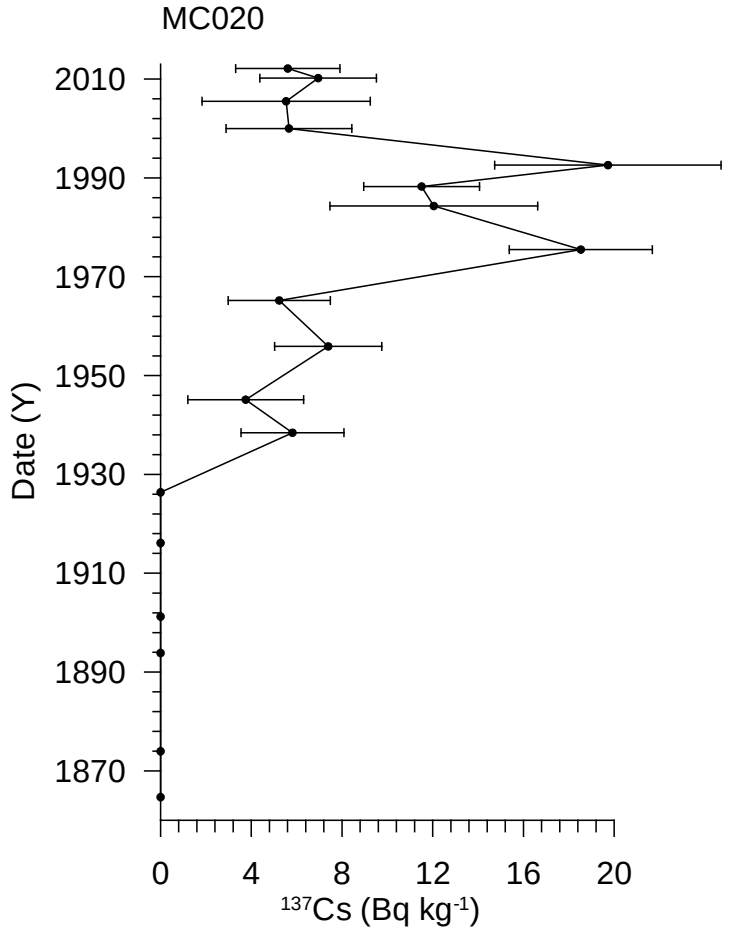
MC020
Date (Y)
2010
1990
1970
1950
1930
1910
1890
1870
0
4
8
12
16
20
137Cs (Bq kg-1)

Fig 4

Gamma Dating Center Copenhagen

Copenhagen, July 14th, 2014

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Dating of core R1146MC011KA

Dating of core R1146MC011KA

Methods

The samples have been analysed for the activity of ^{210}Pb, ^{226}Ra and ^{137}Cs via gammaspectrometry at the Gamma Dating Center, Institute of Geography, University of Copenhagen. The measurements were carried out on a Canberra ultralow-background Ge-detector. ^{210}Pb was measured via its gamma-peak at 46,5 keV, ^{226}Ra via the granddaughter ^{214}Pb (peaks at 295 and 352 keV) and ^{137}Cs via its peak at 661 keV.

Results

The core showed surface contents of unsupported ^{210}Pb of around 210 Bq kg-1 with a clear tendency for exponential decline with depth in the upper 10 cm (fig 1). Below this depth the activity was below detection limits. The calculated flux of unsupported ^{210}Pb is about 540 Bq m^{-2} y^{-1} which is about an order of magnitude higher that the estimated atmospheric supply to the site (based on data in Appleby, 2001). This shows that the site is subject to intense sedimentation.

The content of ^{137}Cs was generally very low and below detection limit at depths deeper than 11 cm.

CRS-modelling has been applied on the profile using a modified method (Appleby, 2001) where the activity below 10 cm is calculated on the basis of the regression shown in fig 2. The result is given in table 2 and fig 3 and 4.

The chronology given in table 2 is only valid if bioturbation and other sediment mixing is negligible. If this is not the case, ages given in table 2 are underestimated and accumulation rates are overestimated. The clear tendency for exponential decline in the activity and the high inventory of unsupported ^{210}Pb suggests that the chronology is reliable and that the site has been subject to intense sedimentation after around 1990. Layers below 10 cm depth are deposited at least 100 years ago. Alternatively, the site is subject to sediment slumping but without any slumping since 1990.

Copenhagen, July 14th, 2014

Thorbjørn J Andersen

Reference:

Appleby, P.G. (2001): Chronostratigraphic techniques in recent sediments. In: Last, W.M & Smol, J.P. (eds) Tracking environmental change using lake sediments. Volume 1: Basin analysis, coring and chronological techniques. Kluwer Academic Publishers, the Netherlands.

Table 1. Raw data, R1146MC011KA

Depth cm	Pb-210tot Bq kg-1	error Pb-210 tot Bq kg-1	Pb-210 sup Bq kg-1	error Pb-210 sup Bq kg-1	Pb-210 unsup Bq kg-1	error Pb-210 unsup Bq kg-1	Cs-137 Bq kg-1	error Cs-137 Bq kg-1
0.5	240	22	21	12	219	34	2	2
1.5	239	20	25	3	215	24	0	0
2.5	192	19	26	0	166	19	0	0
3.5	163	14	19	5	144	19	1	2
4.5	175	15	18	11	157	26	4	2
5.5	154	14	27	10	127	24	0	0
6.5	173	12	27	3	146	16	4	2
7.5	130	10	22	1	108	11	2	1
8.5	180	15	14	10	167	26	4	2
9.5	108	9	20	3	87	12	2	2
10.5	6	1	23	10	1	11	2	2
11.5	24	4	19	3	4	7	0	0
13.5	4	1	20	2	1	3	0	0
34.5	5	1	23	3	1	4	0	0

Table 2, Chronology core R1146MC011KA

Depth cm	Age (y)	error age (y)	Date (y)	acc rate (kg m-2 y-1)	error rate (kg m-2 y-1)	Date acc rate (y)
			2013			
0.5	1	3	2012	2.43	0.44	2013
1.5	3	3	2010	2.33	0.36	2011
2.5	5	4	2008	2.49	0.41	2009
3.5	7	4	2006	2.86	0.52	2007
4.5	9	4	2004	2.77	0.58	2005
5.5	12	4	2001	2.74	0.64	2003
6.5	14	4	1999	2.65	0.49	2000
7.5	17	5	1996	2.65	0.51	1998
8.5	20	5	1993	2.25	0.53	1995
9.5	23	6	1990	2.21	0.44	1992
10.5	> 100					

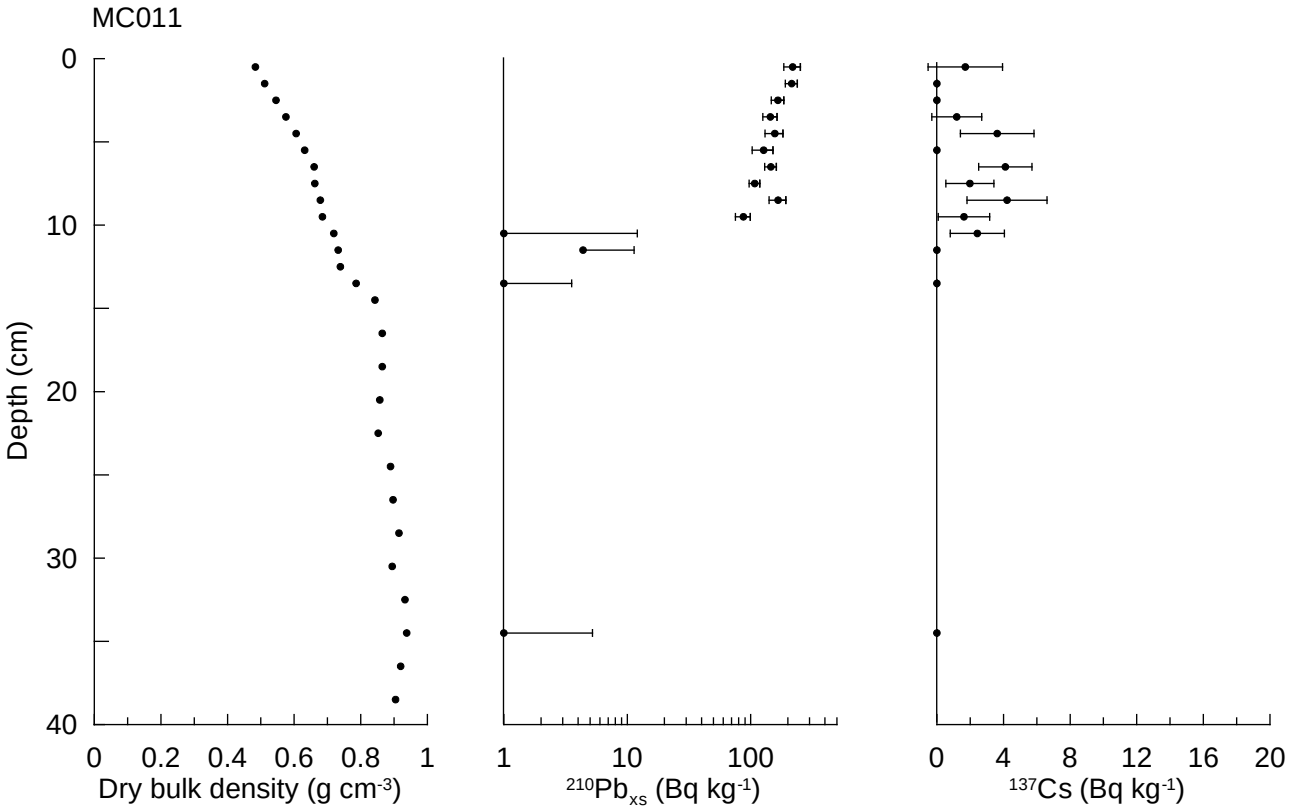

Fig 1

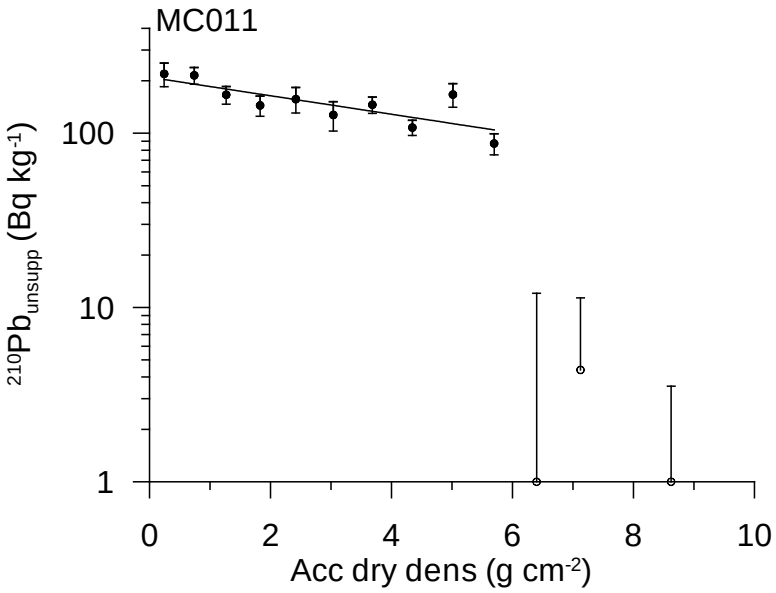

Fig 2. Regression of unsupported ^{210}Pb vs accumulated dry density. Solid circles are included in the analysis, open circles are not.

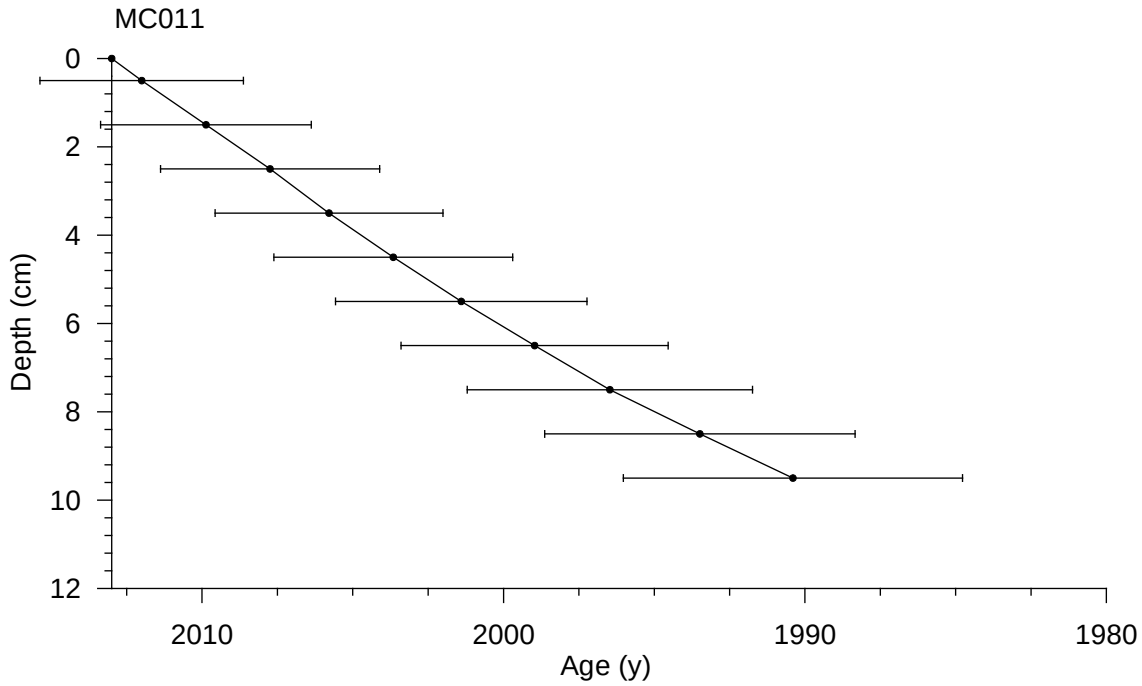
MC011
0
2
4
6
8
10
12
Depth (cm)
2010
2000
1990
1980
Age (y)

Fig 3

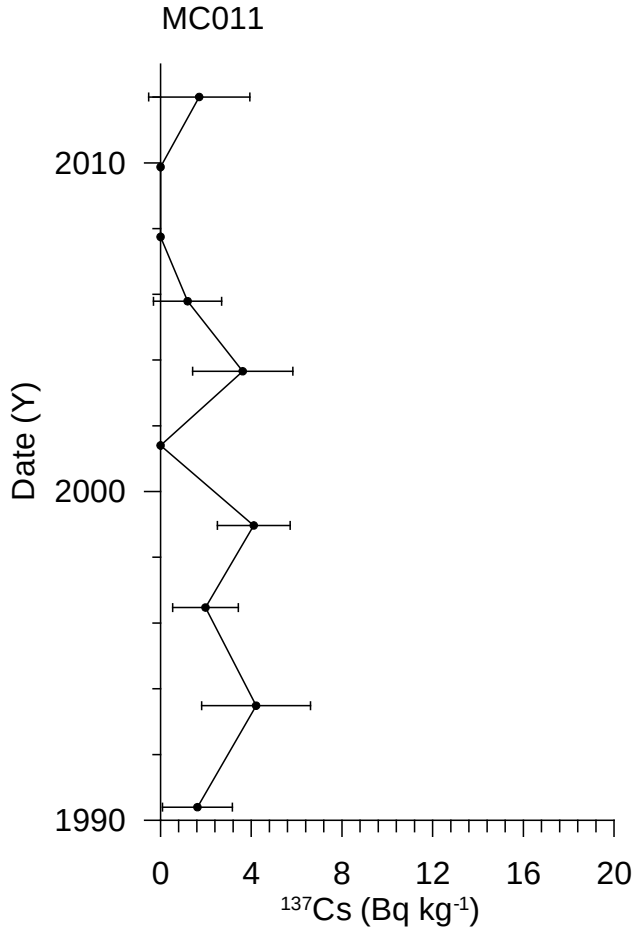
MC011
2010
2000
1990
Date (Y)
0
4
8
12
16
20
137Cs (Bq kg-1)

Fig 4

Gamma Dating Center Copenhagen

Copenhagen, July 14th, 2014

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Dating of core R1165MC012KA

Dating of core R1165MC012KA

Methods

The samples have been analysed for the activity of ^{210}Pb, ^{226}Ra and ^{137}Cs via gammaspectrometry at the Gamma Dating Center, Institute of Geography, University of Copenhagen. The measurements were carried out on a Canberra ultralow-background Ge-detector. ^{210}Pb was measured via its gamma-peak at 46,5 keV, ^{226}Ra via the granddaughter ^{214}Pb (peaks at 295 and 352 keV) and ^{137}Cs via its peak at 661 keV.

Results

The core showed surface contents of unsupported ^{210}Pb of around 180 Bq kg-1 and an irregular profile with depth with a local minimum around 6.5 cm depth. Below this depth the activity increases and only reached equilibrium-levels around 17 cm depth.
The calculated flux of unsupported ^{210}Pb is about 228 Bq m^{-2} y^{-1} which is about three times higher than the estimated atmospheric supply to the site (based on data in Appleby, 2001). This shows that the site is subject to sedimentation.

The content of ^{137}Cs was generally very low and below detection limit at depths deeper than 9 cm.

CRS-modelling has been applied on the profile using a modified method (Appleby, 2001) where the activity below 17 cm is calculated on the basis of the regression shown in fig 2. The result is given in table 2 and fig 3 and 4.

The irregular profile of unsupported ^{210}Pb makes it difficult to interpret the core but the most likely explanation for the observed profile is a period of rapid sedimentation sometime in the mid 1990´s, maybe due to sediment slumping.

Copenhagen, July 14th, 2014

Thorbjørn J Andersen

Reference:

Appleby, P.G. (2001): Chronostratigraphic techniques in recent sediments. In: Last, W.M & Smol, J.P. (eds) Tracking environmental change using lake sediments. Volume 1: Basin analysis, coring and chronological techniques. Kluwer Academic Publishers, the Netherlands.

Table 1. Raw data, R1165MC012KA

Depth cm	Pb-210tot Bq kg-1	error Pb-210 tot Bq kg-1	Pb-210 sup Bq kg-1	error Pb-210 sup Bq kg-1	Pb-210 unsup Bq kg-1	error Pb-210 unsup Bq kg-1	Cs-137 Bq kg-1	error Cs-137 Bq kg-1
0.5	200	18	21	1	180	19	0	0
1.5	147	16	18	1	129	17	4	2
2.5	118	11	18	7	100	18	2	1
3.5	62	7	16	8	46	16	0	0
4.5	56	6	21	4	35	10	4	1
5.5	28	5	17	7	11	11	1	2
6.5	31	4	22	4	9	8	0	0
7.5	61	8	20	4	41	12	2	2
8.5	92	11	20	0	73	11	6	3
9.5	105	13	21	4	84	17	0	0
11.5	101	11	22	7	79	18	0	0
16.5	28	5	24	0	4	5	0	0
22.5	0	13	13	6	0	20	0	0

Table 2, Chronology core R1165MC012KA

Depth (cm)	Age (y)	error age (y)	Date (y)	acc rate (kg m-2 y-1)	error rate (kg m-2 y-1)	Date acc rate (y)
			2013			
0.5	2	2	2011	1.23	0.15	2012
1.5	7	2	2006	1.29	0.19	2009
2.5	11	3	2002	1.52	0.28	2004
3.5	14	3	1999	2.12	0.73	2001
4.5	16	3	1997	3.52	1.02	1998
5.5	17	3	1996	5.92	6.21	1996
6.5	18	3	1995	13.49	12.91	1995
7.5	19	3	1994	5.14	1.55	1994
8.5	23	3	1990	2.08	0.36	1992
9.5	29	4	1984	1.31	0.26	1987
11.5	46	6	1967	0.89	0.18	1976
16.5	120	34	1893	0.51	0.55	1930
22.5	> 120					

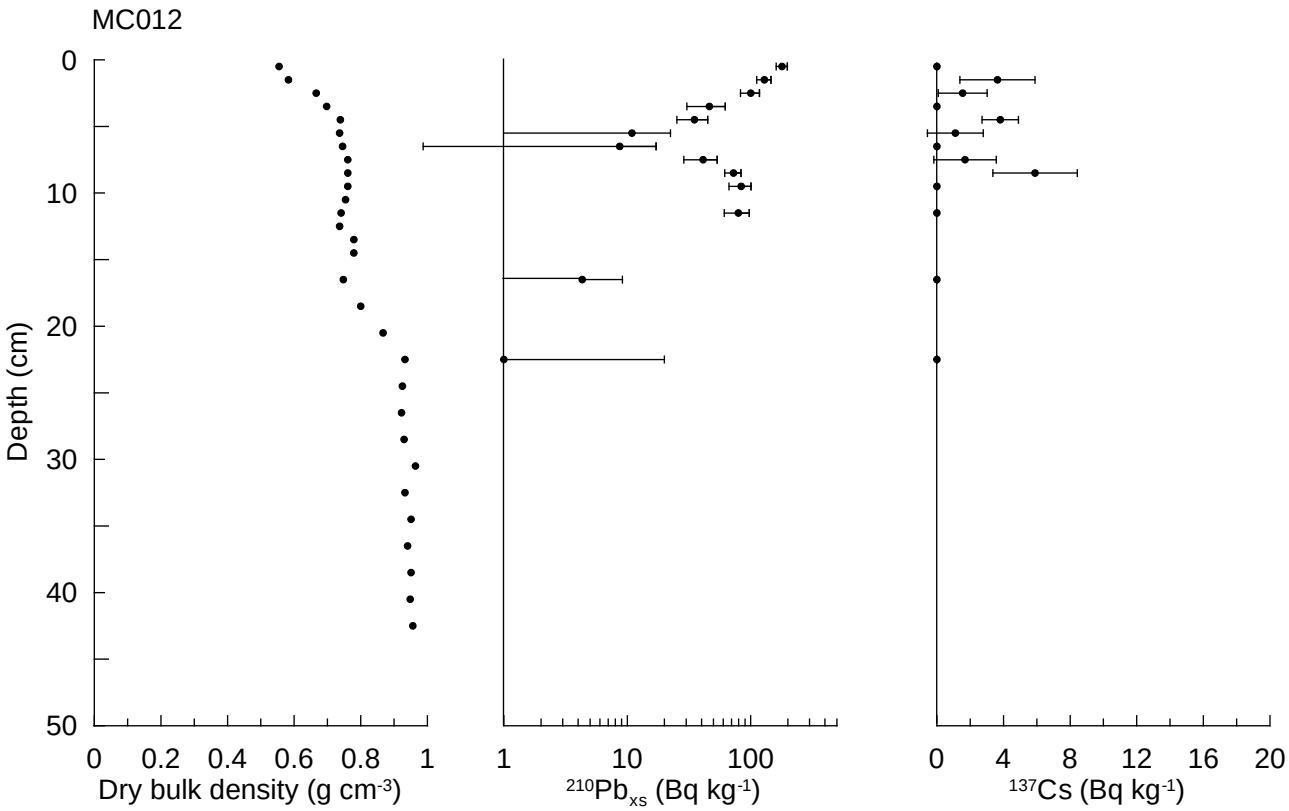

Fig 1

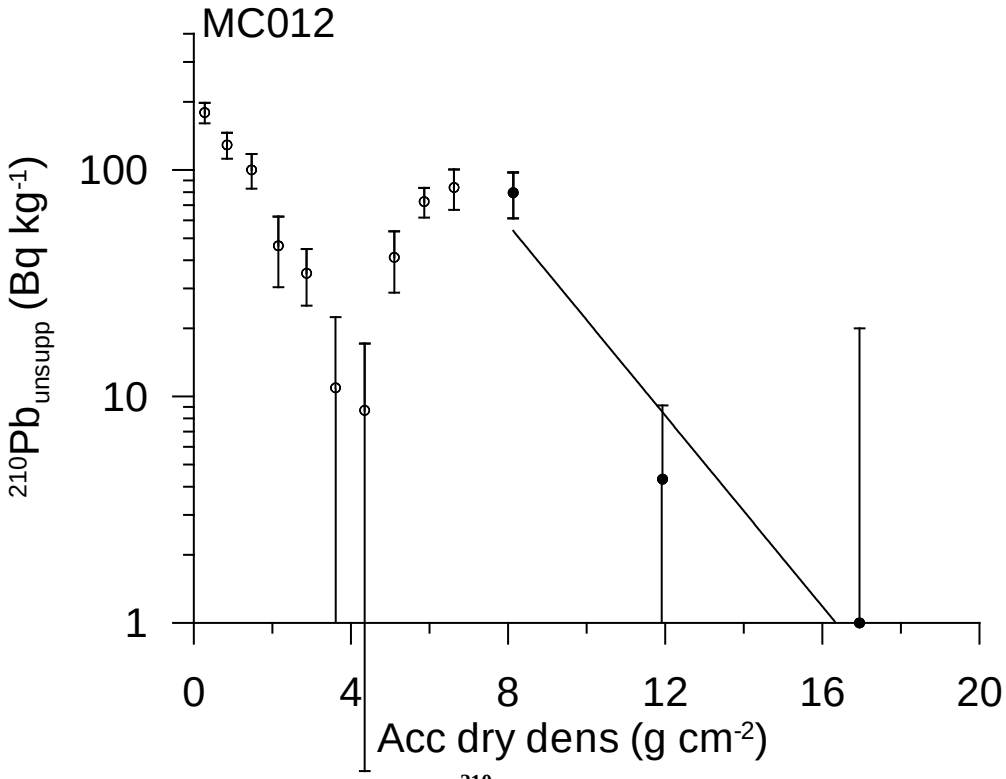

Fig 2. Regression of unsupported ^{210}Pb vs accumulated dry density. Solid circles are included in the analysis, open circles are not.

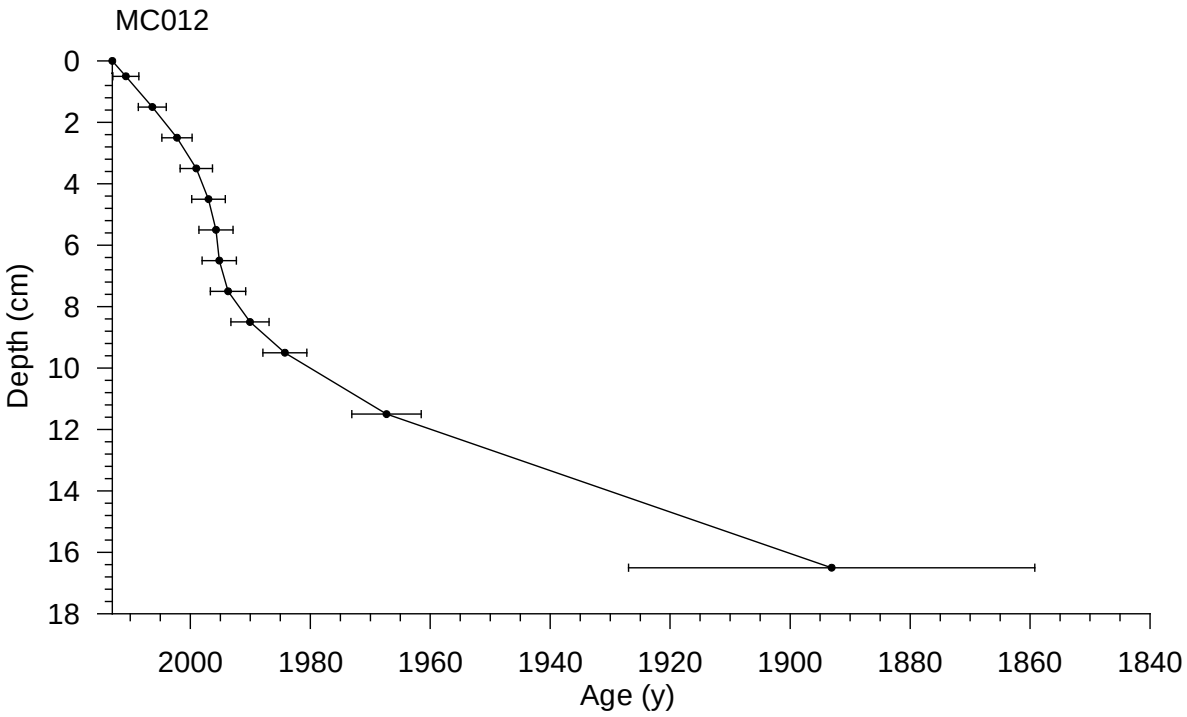
MC012
Depth (cm)
0
2
4
6
8
10
12
14
16
18
2000
1980
1960
1940
1920
1900
1880
1860
1840
Age (y)

Fig 3

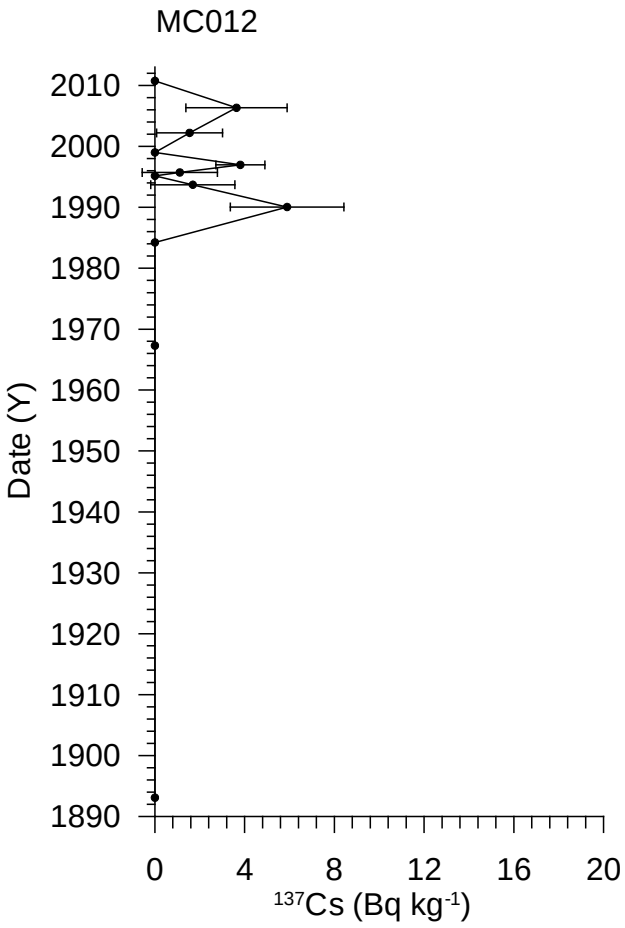
MC012
Date (Y)
2010
2000
1990
1980
1970
1960
1950
1940
1930
1920
1910
1900
1890
0
4
8
12
16
20
137Cs (Bq kg-1)

Fig 4

Gamma Dating Center Copenhagen

Copenhagen, July 1st, 2014

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Dating of core R1200MC016KA

Dating of core R1200MC016KA

Methods

The samples have been analysed for the activity of ^{210}Pb, ^{226}Ra and ^{137}Cs via gammaspectrometry at the Gamma Dating Center, Institute of Geography, University of Copenhagen. The measurements were carried out on a Canberra ultralow-background Ge-detector. ^{210}Pb was measured via its gamma-peak at 46,5 keV, ^{226}Ra via the granddaughter ^{214}Pb (peaks at 295 and 352 keV) and ^{137}Cs via its peak at 661 keV.

Results

The core showed very low contents of both unsupported ^{210}Pb and ^{137}Cs. Based on this is must be concluded that the core is from a site with erosion or at least no deposition. Alternatively the top of the sediment is not retrieved in the core.

It is not possible to calculate a chronology for the core but the sediment was deposited at least 100 years ago.

Copenhagen, July 1st, 2014

Thorbjørn J Andersen

Table 1. Raw data, R1200MC016KA

Depth cm	Pb-210tot Bq kg-1	error Pb-210 tot Bq kg-1	Pb-210 sup Bq kg-1	error Pb-210 sup Bq kg-1	Pb-210 unsup Bq kg-1	error Pb-210 unsup Bq kg-1	Cs-137 Bq kg-1	error Cs-137 Bq kg-1
0.5	15	3	15	0	0	3	0	0
1.5	20	3	15	0	5	3	0	0
2.5	12	2	14	1	0	2	1	1
3.5	4	1	13	1	0	1	0	0
4.5	2	0	14	2	0	2	0	0
8.5	0	0	13	2	0	2	0	0

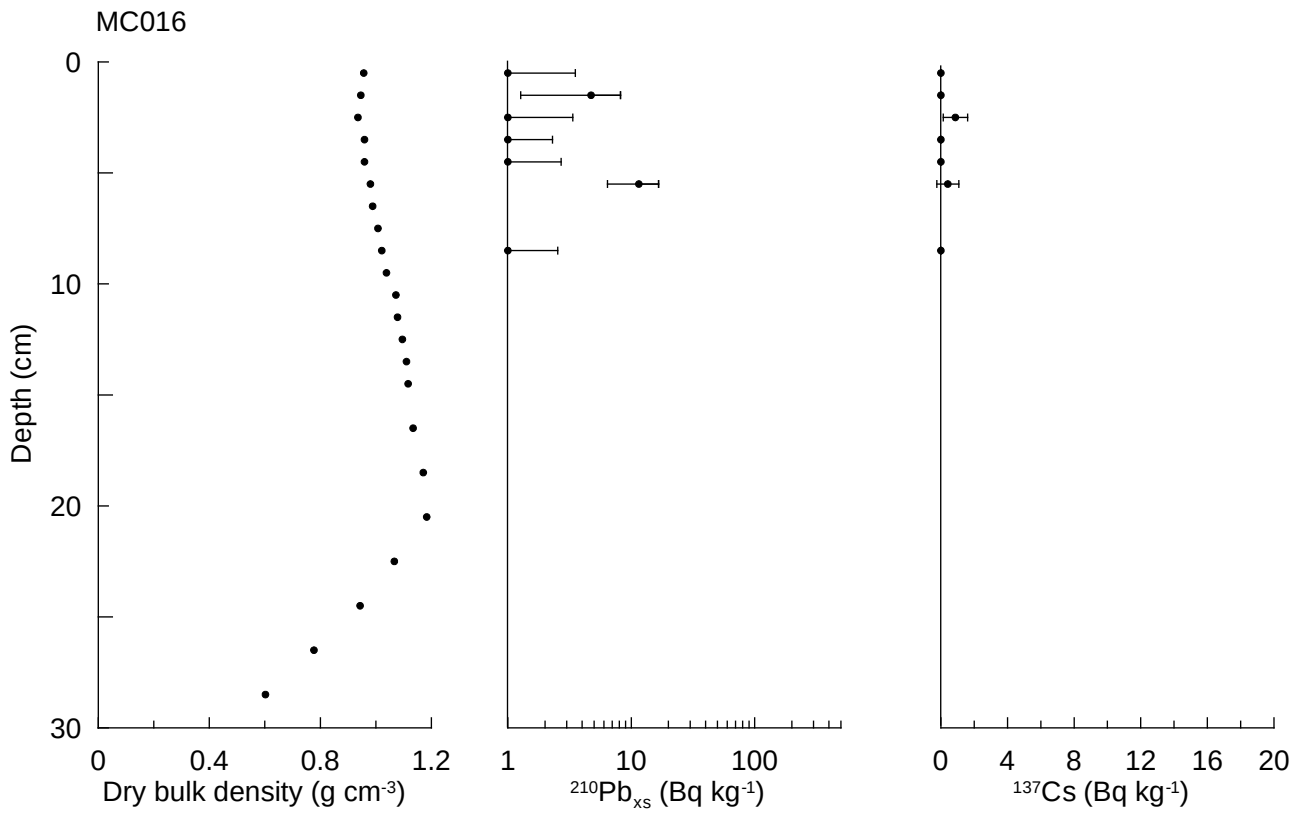

Fig 1