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ISOTOPIC INVESTIGATIONS OF UPPERMOST SEDIMENTS FROM LAKE WIGRY (NE POLAND) AND ITS ENVIRONMENT

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Abstract: **This paper presents the results of the first isotopic investigations of sediments recovered from Lake Wigry (NE-Poland). In the spring/summer 2002 few sediment cores, plant samples and water profiles were collected specially for isotopic investigations. We obtained ^{210}Pb activity profiles, ^{137}Cs activity profiles and ^{14}C activity/age profiles. Apparent ages of carbonate fraction for all sediment cores were determined. Sedimentation rates for collected cores were estimated using ^{14}C dating method. In addition oxygen isotopic ratios of the water profiles, carbon stable isotopes ratio of collected sediment cores were determined.**

1. INTRODUCTION

Radioisotopic methods are widely used in the investigations of lakes sediments. These are the main tools for determination of modern sedimentation rates and estimation of sedimentation rate changes in the past. Using carbon natural radioisotope – ^{14}C one may try to determine age of a lake (time when lake formation started). It is commonly done by analyzing of ^{14}C age of most bottom part of lake sediments. To be accurate in these determinations the apparent age of sediments must be known or when available terrestrial macro-fossils separated form the most bottom part of lake sediment have to be dated. Apparent age is caused by reservoir effect, which occurs when carbon in a sample has other sources than atmospheric CO_2 (Broecker and Walton, 1959). Radiocarbon apparent age of sediment may be estimated by obtaining of ^{14}C age of the top layer of sediments, which is assumed to be modern, unfortunately for some lakes this methods is not correct because of the reservoir effect variations in time (Pazdur *et al.,* 1995; Geyh *et al.,* 1998). Stable isotopes, on the other hand are useful when analyzing lake dynamics and processes that influence the carbon and oxygen sources in lakes. Isotopic investigations may provide information not only about the lake, but also about its surrounding i.e., the whole lake ecosystem. Moreover, complete isotopic investigation should not only focus on the lake bottom sediments, but also on sedimentation environment. Such approach gives a chance to study history and modern behavior of lake ecosystem and its dynamics (cf. Ralska-Jasiewiczowa *et al.,* 1998; Pawlyta, 1999)

2. SITE

Lake Wigry is located in the Suwałki Lakeland, NE Poland (54°00 ' N, 23°01' E). Localization of Lake Wigry is presented in **Fig. 1**. It is one of the biggest and deepest lakes in Poland. Together with 41 lakes in its vicinity, Lake Wigry forms Wigry National Park. Characteristics of Lake Wigry are presented in **Table 1**. Lake Wigry is a relatively large mezotrophic lake consisting of few main basins connected by straights which together with bays and islands divide the lake waters into few different regions.

The surrounding area was shaped during Baltic Glaciation, which peaked between 20,000 and 15,000 (^{14}C) years ago. During this time the northern part of the present area of the Wigry National Park was covered by ice, while the southern part was the area where accumulation of glacial material coming from the front of the ice occurred. All of the Wigry National Park lakes were formed by retreated glacier. Lake Wigry is elongated ribbon-like lake. All lakes which belong to the Wigry National Park are either marginal or thaw lakes. Most of Lake Wigry sediments are carbonate gyttja containing about 70% of $CaCO_3$ in silt and clay fractions. In the area of the Wigry National Park most of the lakes are mezoeutrophic with calcium reach water, but in the surrounding forests small polihumic lakes (with brown water) are also located. These area includes many springs, streams, rivers and few diverse types of wetlands.

Because of the special value of the Wigry National Park many interdisciplinary studies have been conducted, but the lake history is not well known yet. This is the first effort of using different isotopic methods to investigate Lake Wigry and its environment. We hope that our first systematic isotopic investigations will help to reconstruct history of Lake Wigry sediments.

Lake Wigry is not uniform and therefore different types of sampling sites were selected. Selection of coring sites was made as a result of preceding seismoacoustic investigations (Rutkowski *et al.,* 2002). Sediment cores were sampled for carbon and oxygen stable isotopes analyzes, determination of ^{137}Cs profiles and ^{14}C and ^{210}Pb dating. Also two water profiles were collected for oxygen isotopes analyzes. First results of these analyzes are presented.

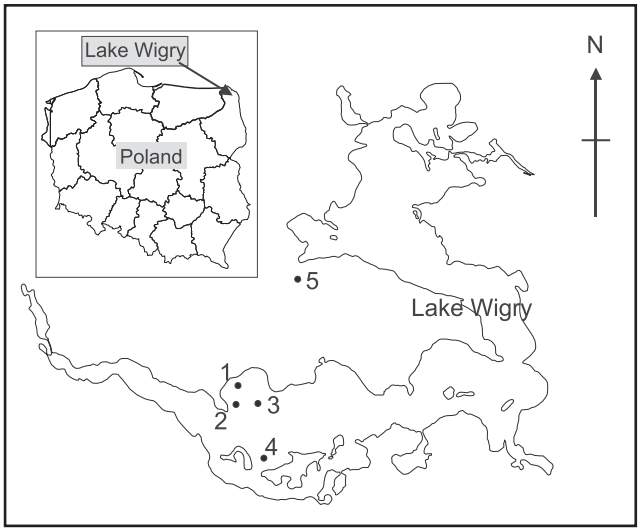

Fig 1. *Location of Lake Wigry and of sampling sites. 1 – WZS/581, 2 – WZS/580, 3 – WZS/406, 4 – WSG/411, 5 – WSD/412*

Table 1. *Characteristics of Lake Wigry*

Water surface	2118.3 ha
Total catchment	453.7 km^2
Surface of islands	68.4 ha
Water exchange rate	0.36 yr^{-1}
Total volume	336.7·10^6 m^3
Max. length	17.5 km
Max depth	73 m
Mean depth	15.8 m

3. METHODS

In the spring/summer of 2002 five cores of youngest part of the sediment were taken. Coring was made using piston corer. The cores were sampled for investigations of isotopic and physical properties of sediment. All coring sites are shown in **Fig. 1**. Characteristics of cores are presented in **Table 2**. Because of unknown sedimentation rate the investigated sites we used different dating methods to investigate collected so called "short cores". In order to cover the last few decades we decided to investigate ^{137}Cs (Ritchie and McHenry, 1990; Walling D.E. and He Q., 1993) profiles in the cores. The lead ^{210}Pb method was used to cover the last century (Goldberg, 1963; Eakins, 1983; Krishnaswami *et al.*, 1971; Liu J. *et al.*, 1991) and the radiocarbon dating method to cover the whole time range (*ca* 10,000 yrs).

Cores were sampled with a resolution of few centimeters. The ^{137}Cs and ^{210}Pb activities were measured in a bulk dried sediment sample material, then ^{14}C, ^{13}C, and ^{18}O investigations were made. Description of sampling sites and cores is given in **Table 2**.

Measurements of ^{14}C concentration

^{14}C activity was determined for samples taken form cores WSG/411/02, WZS/406/02 and WSD/412/02. ^{14}C activity was measured using gas proportional counters filled with CO_2 gas. The CO_2 was prepared by combustion of organic material in the oxygen flow or by decomposition of carbonate samples with a use of hydrochloric acid. Produced CO_2 was then purified in vacuum rigs to obtain required purity. Measurements were carried out with one of our gas proportional counter whichever best fitted the volume of the CO_2 sample (Pazdur *et al.*, 2000; Pazdur *et al*., 2003). All radiocarbon measurements results were corrected for isotopic fractionation. Calculations and presentation of results were done according to Stuiver and Polach (1977).

Table 2. *Characteristics of investigated cores*

Coring site	Core name	Overlying water column (m)	Sediment
Słupiańska Bay (Lake Wigry)	WZS/406/02	21	carbonate gyttja
Słupiańska Bay (Lake Wigry)	WZS/580/02	25	carbonate gyttja
Słupiańska Bay (Lake Wigry)	WZS/581/02	28	carbonate
Lake Suchar Dembowskich	WSD/412/02	25	dark organic gyttja
Sielawa Góra Shallow(Lake Wigry)	WSG/411/02	2	carbonate

Measurements of stable isotopes ratios

Determination of $\delta^{13}C$ for organic samples (core WSD/412/02) was done on fraction of carbon dioxide prepared for gas proportional counters. Determination of $\delta^{13}C$ and $\delta^{18}O$ for carbonate sediments were done by decomposition of carbonate using phosphoric acid in the vacuum rig directly connected to the mass spectrometer. Determination of $\delta^{18}O$ for water samples was done using equilibration method. All results of $\delta^{13}C$ and $\delta^{18}O$ determinations are given in respect to PDB standard.

Measurements of ^{137}Cs radioactivity

The concentration of ^{137}Cs was determined in five sediment cores (WZS/406/02, WSG/411/02, WSD/412/02, WZS/580/02 and WZS/581/02). The cores were sectioned in 5 cm intervals. Only for one core (WSD/412/02) the intervals were bigger. All samples were dried until their mass was constant. The ^{137}Cs concentration was measured by means of a gamma spectrometry method (Poręba *et al*., 2003). Because of small masses of samples (less than 2 g), a high-resolution well type germanium gamma detector was used. The measurement time for each sample was approximately 72 h. The 661.7 keV gamma-ray peak from the gamma-ray spectrum was used to calculate ^{137}Cs activity. The activity of ^{137}Cs in lake sediments were expressed in Bq/kg of dry mass of sediment and corrected for the time elapsed since sample collection.

Measurements of ^{210}Pb radioactivity

^{210}Pb activity was determined for samples taken from cores WZS/580/02 and WZS/581/02.

Measurements of ^{210}Pb activity were done independently by alpha and gamma ray spectrometry methods (Sikorski and Goslar, 2003; Sikorski and Bluszcz, 2003). With the alpha ray spectrometry method quantity and energy of alpha particles emitted by ^{210}Po were measured. ^{210}Po is formed after two consecutive decays of ^{210}Pb and then ^{210}Bi and is assumed to be in secular equilibrium with the former. ^{210}Po was chemically separated from the sediment material and deposited as a thin source on a silver substrate. The gamma ray spectrometry on the other hand requires measurements of gamma photons emitted by ^{210}Pb, ^{214}Pb and ^{214}Bi isotopes. Analysis of ^{210}Pb gamma spectrum yields information about total activity of lead 210, while the assessed activity of ^{214}Pb and ^{214}Bi equals to the activity of authigenic ^{210}Pb. Small masses of samples (about 1.5 g), and a low energy of gamma photons emitted by ^{210}Pb (E_{210Pb} = 46.5 keV) required the utilisation of a thin–wall HPGe coaxial detector with a well-type counting geometry (Sikorski, 2003). Counting time of 1000 minutes was chosen for preliminary measurements.

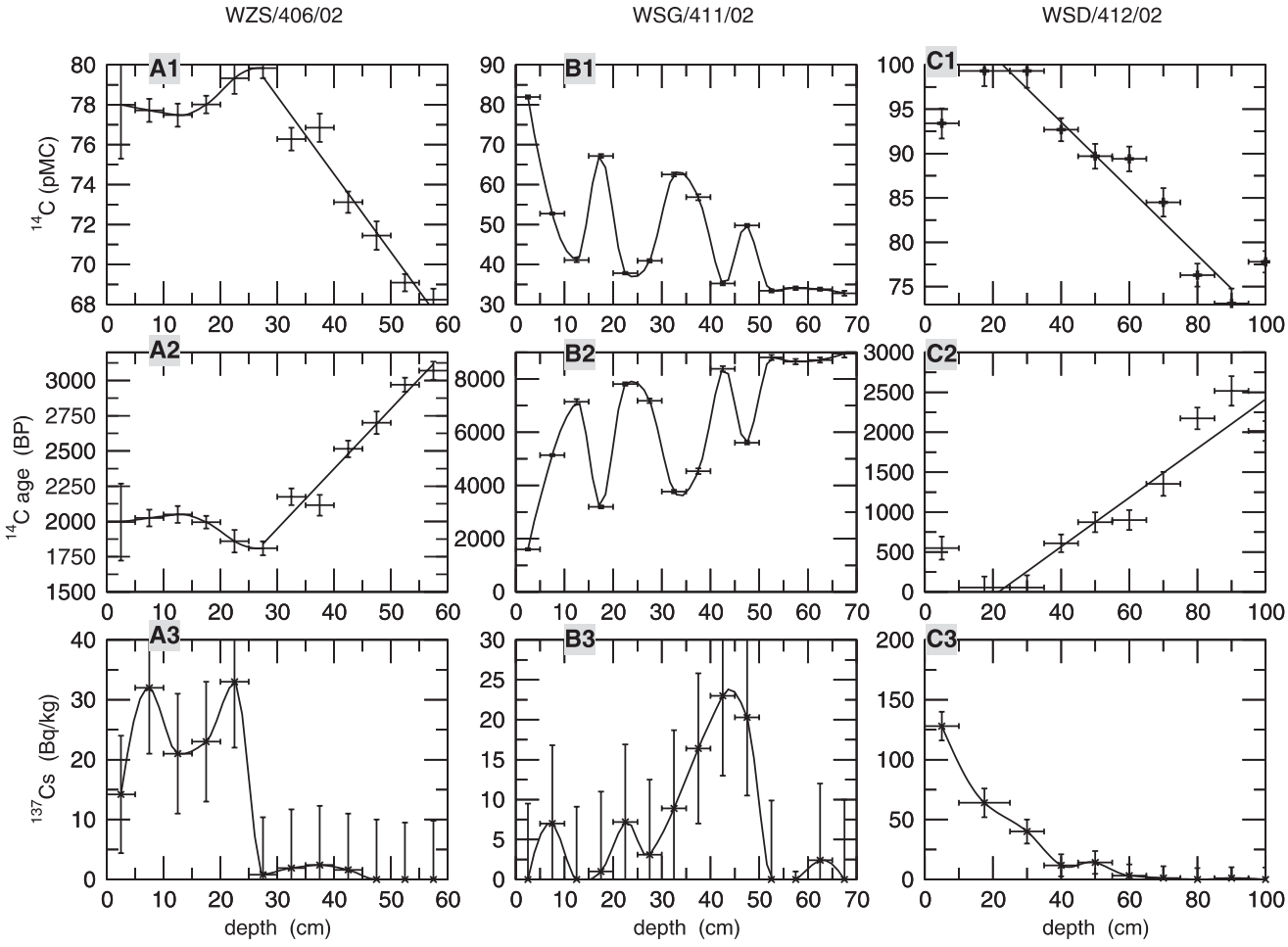

Fig 2. *Changes of ^{14}C radioactivity (row 1), conventional radiocarbon age (row 2) and ^{137}Cs radioactivity (row 3) in the sediment profiles for cores: WZS/406/02 (column A), WSG/411/02 (column B), WSD/412/02 (column C)*

4. RESULTS

^{14}C concentration

Results of ^{14}C concentration determinations are shown in **Fig. 2 A1, Fig. 2. B1, Fig. 2 C1** and in **Table 3**. It is evident that for core WSG/411/02 sediment material is probably mixed in the whole investigated depth. We suppose that mixing occurs because Sielawa Góra shallow may be used by fishers as mooring area. For cores WZS/406/02 and WSD/412/02 starting from the depth of 27.5 cm there is a linear dependence of ^{14}C activity versus depth. The increase of ^{14}C activity with depth in the range of 0 to 27.5 cm for cores WZS/406/02 and WSD/412/02 may be interpreted as a result of nuclear weapon tests induced changes in the atmosphere. Isotopic dilution factor defined as:

$$q_0 = {}^{14}C_s / {}^{14}C_{std}\,, \qquad (4.1)$$

where $^{14}C_s$ is radiocarbon activity of the topmost sample in the core and $^{14}C_{std}$ is radiocarbon activity of standard of contemporary biosphere was calculated for three investigated cores (**Table 6**). Isotopic dilution factor for both carbonate cores recovered from Lake Wigry is similar.

$$T_r = -8033 \ln(q_0) \qquad (4.2)$$

is called apparent age or reservoir age (Pazdur *et al.,* 1995), which is the conventional radiocarbon age of the topmost sample of the core. In case of undisturbed cores, because the depth - age dependence is linear below 27.5 cm, we assumed that apparent ages are constant and basing on this assumption we corrected age of all samples to obtain conventional radiocarbon age. Results of q_0 and T_r calcu-

Table 3. *Table 3. Results of carbon and oxygen isotopes investigations. Uncertainties for $\delta^{13}C$ and $\delta^{18}O$ were better or equal to 0.1‰. C = carbonate fraction, O = organic fraction*

Sample name	Lab. code	Depth (cm)	Material	^{14}C (pMC)	T_{CONV} (BP)	$\delta^{13}C$(‰, PDB)	$\delta^{18}O$ (‰, PDB)
			CORE WZS/406/02				
WZS/406/02/0-5	Gd-18178	0-5	C	78.0±2.7	2000±280	-4.00	-9.36
WZS/406/02/5-10	Gd-12471	5-10	C	77.72±0.58	2025±60	-4.55	-9.25
WZS/406/02/10-15	Gd-12477	10-15	C	77.48±0.58	2050±60	-4.33	-9.21
WZS/406/02/15-20	Gd-12470	15-20	C	78.01±0.44	1995±45	-6.55	-8.99
WZS/406/02/20-25	Gd-15439	20-25	C	79.33±0.79	1860±80	-3.79	-9.14
WZS/406/02/258-30	Gd-12478	25-30	C	79.83±0.50	1810±50	-4.78	-9.35
WZS/406/02/30-35	Gd-12484	30-35	C	76.28±0.57	2175±60	-5.11	-9.04
WZS/406/02/35-40	Gd-15460	35-40	C	76.85±0.71	2115±75	-4.60	-8.88
WZS/406/02/40-45	Gd-12481	40-45	C	73.12±0.54	2515±60	-4.32	-8.53
WZS/406/02/45-50	Gd-12469	45-50	C	71.45±0.71	2700±80	-4.72	-8.68
WZS/406/02/50-55	Gd-12486	50-55	C	69.09±0.43	2970±50	-5.35	-8.96
WZS/406/02/55-60	Gd-12474	55-60	C	68.24±0.55	3070±65		
			CORE WSG/411/02				
WSG/411/02/0-5	Gd-12473	0-5	C	81.94±0.41	1600±40	-2.75	-8.76
WSG/411/02/5-10	Gd-12489	5-10	C	52.74±0.29	5140±45	-3.46	-8.72
WSG/411/02/10-15	Gd-12493	10-25	C	41.09±0.51	7145±100	-4.03	-8.64
WSG/411/02/15-20	Gd-12490	15-20	C	67.18±0.46	3195±55	-3.75	-8.57
WSG/411/02/20-25	Gd-12491	20-25	C	37.82±0.30	7810±65	-4.29	-8.44
WSG/411/02/25-30	Gd-12476	25-30	C	40.91±0.43	7180±85	-2.82	-8.55
WSG/411/02/30-35	Gd-12488	30-35	C	62.54±0.50	3770±65	-2.96	-8.03
WSG/411/02/35-40	Gd-12479	35-40	C	56.86±0.74	4535±110	-3.16	-8.68
WSG/411/02/40-45	Gd-12494	40-45	C	35.23±0.44	8380±100	-3.90	-8.35
WSG/411/02/45-50	Gd-12495	45-50	C	49.77±0.40	5605±65	-3.88	-8.75
WSG/411/02/50-55	Gd-12496	50-55	C	33.40±0.41	8810±100	-3.37	-8.27
WSG/411/02/55-60	Gd-12500	60-65	C	34.07±0.40	8650±110	-3.36	-8.26
WSG/411/02/60-65	Gd-12499	65-70	C	33.81±0.42	8710±100	-5.44	-8.57
WSG/411/02/65-70	Gd-12497	70-75	C	32.80±0.61	8960±150	-3.75	-9.08
			CORE WSD/412/02				
WSD/412/02/0-5	Gd-17167	0-5	O	93.4±1.7	550±150	-26.00	
WSD/412/02/10-25	Gd-18174	10-25	O	99.3±1.7	55±140	-27.33	
WSD/412/02/25-35	Gd-18172	25-30	O	99.3±1.9	55±160	-29.17	
WSD/412/02/35-45	Gd-16159	35-45	O	92.7±1.3	610±120	-26.86	
WSD/412/02/45-55	Gd-17160	45-55	O	89.7±1.4	870±130	-25.87	
WSD/412/02/55-65	Gd-17158	55-65	O	89.4±1.4	900±130	-26.50	
WSD/412/02/65-75	Gd-16166	65-75	O	84.5±1.6	1350±160	-25.50	
WSD/412/02/75-85	Gd-17163	75-85	O	76.3±1.3	2170±140	-24.25	
WSD/412/02/85-95	Gd-18169	85-95	O	73.1±1.7	2520±190	-24.50	
WSD/412/02/95-105	Gd-16162	95-105	O	77.8±1.2	2020±130	-25.68	

lations are given in **Table 6**. Results of determination of corrected radiocarbon age for all samples are given in **Table 7**.

^{210}Pb radioactivity

Results of ^{210}Pb radioactivity measurements are presented in **Fig. 3**. Sediment below 10 cm depth cannot be dated using ^{210}Pb dating method because only authigenic ^{210}Pb was found there. Average present sedimentation rate for lake Wigry estimated using ^{210}Pb dating method is in the range of $0 < r_{max} < 0.67$ mm/yr, calculated maximum mass sedimentation rate of present sedimentation is in the range of $0.068 < r_{max} < 0.079$ gcm^{-2}yr^{-1}.

The five cm resolution of sampling for sediment cores taken from Lake Wigry is insufficient for the ^{210}Pb method dating. Moreover, additional difficulty is a lack of material from the section between 5 to 10 cm in sampled cores.

^{137}Cs radioactivity

Cesium occurs in all examined sediment cores and its content varies in a large range (**Figs 2 and 3**). The highest concentration of ^{137}Cs was found in the core WSD/412/02. A small amount of cesium was found in sediment from core WSG/412/02. For the core WZS/406/02 small concentration of cesium was found in first sediment layer. The comparison of the vertical distributions of ^{137}Cs in

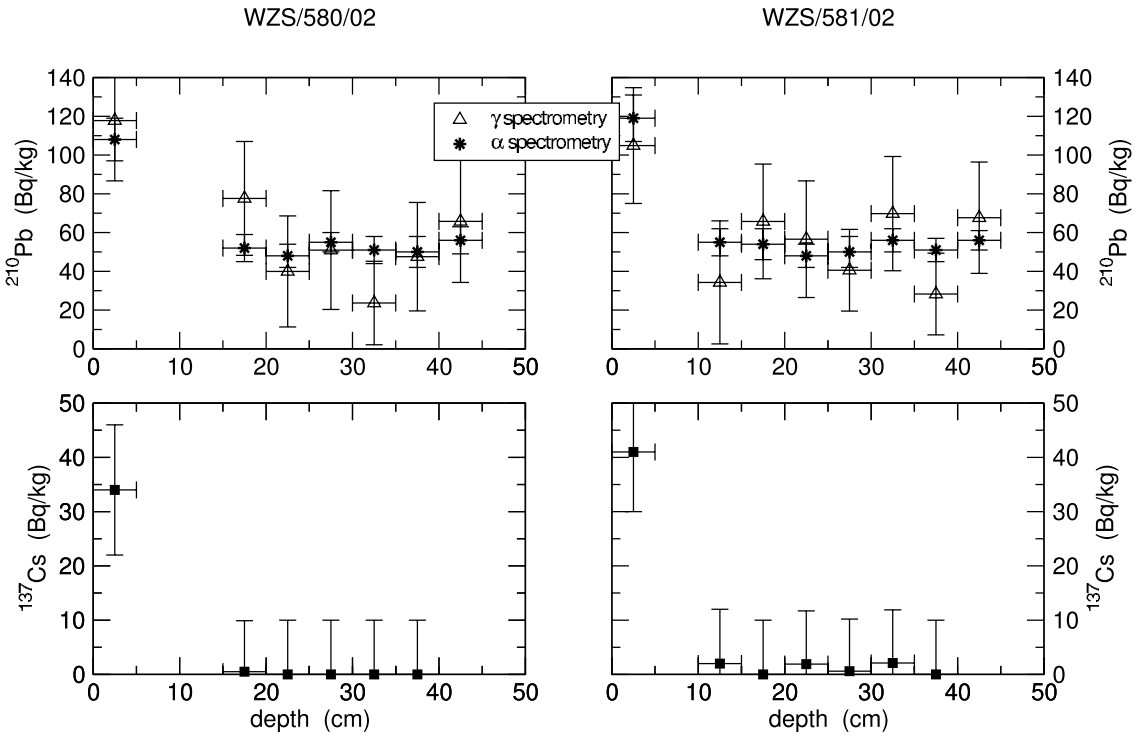

Fig 3. *Changes of ^{210}Pb and ^{137}Cs radioactivity in the sediment profiles*

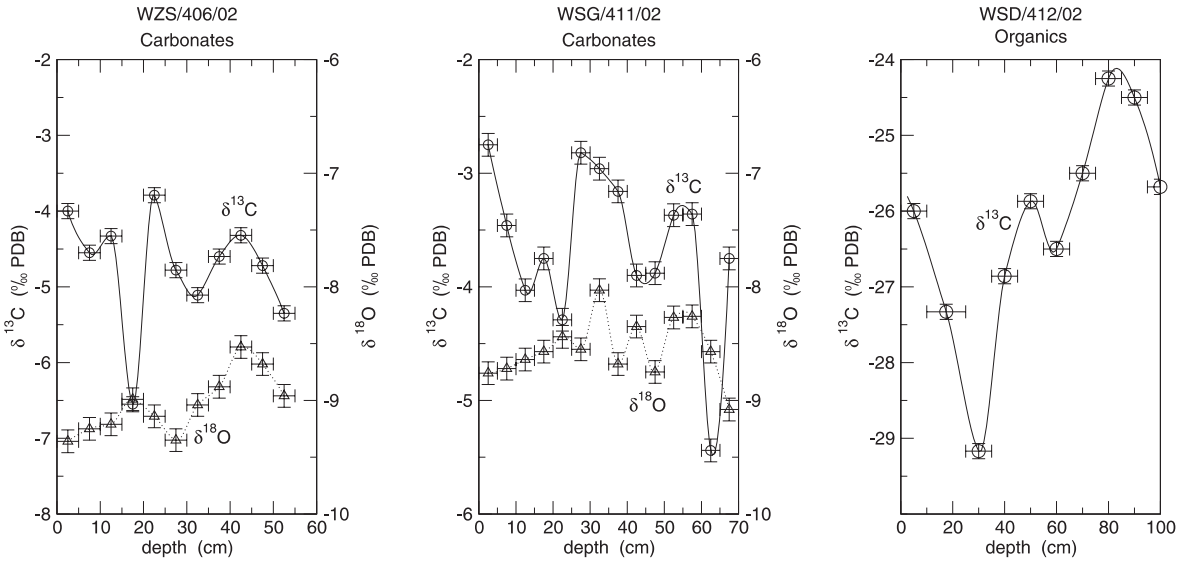

Fig 4. *Changes of carbon and oxygen stable isotopes composition in sediment profiles*

sediments with the known time deposition of the atmospheric ^{137}Cs fallout is impossible in this case. It should be noted that the sampling resolution for ^{137}Cs dating method of sediment cores, which were taken from lake Wigry, was not sufficient.

Stable isotopes

Results of the stable isotopes ratios determinations for sediment material are given in **Fig. 4** and **Table 3**. Results of the stable isotopes ratios of oxygen for water samples are given in **Fig. 5** and **Table 6**. Relatively large fluctuations of $\delta^{13}C$ and $\delta^{18}O$ in the WSG/411/02 confirm mixing of sediment in the profile.

Oxygen stable isotopes ratio profile for two water samples/or columns gives similar values, so we believe that the conditions in water columns in two sampling sites were also similar. Both water profiles were sampled in the same bay – Słupiańska Bay and in the same time (summer 2002), so it may be concluded that probably the whole bay is supplied with water from the same sources.

5. DISCUSSION AND CONCLUSIONS

This study presents the results of the pilot isotopic investigations carried on sediments and on water samples from Lake Wigry. This first results provide a base for future

Table 4. *Results of ^{210}Pb activity determinations and laboratory uncertainties*

Sample name	Depth (cm)	^{210}Pb Activity (Bq/kg)	^{210}Pb Activity (Bq/kg)
		alpha spectrometry	gamma spectrometry
	Core WZS/580/02		
WZS/580/02/0-5cm	0-5	118 ± 31	108 ± 11
WZS/580/02/5-10cm	0-10		
WZS/580/02/10-15cm	10-15		
WZS/580/02/15-20cm	15-20	78 ± 29	52.0 ± 7.0
WZS/580/02/20-25cm	20-25	40 ± 29	48.0 ± 6.0
WZS/580/02/25-30cm	25-30	51 ± 31	55.0 ± 5.0
WZS/580/02/30-35cm	30-35	24 ± 22	51.0 ± 7.0
WZS/580/02/35-40cm	35-40	48 ± 28	50.0 ± 8.0
WZS/580/02/40-45cm	40-45	66 ± 31	56.0 ± 7.0
	Core WZS/581/02		
WZS/581/02/0-5cm	0-5	105 ± 30	119 ± 12
WZS/581/02/5-10cm	0-10		
WZS/581/02/10-15cm	10-15	34 ± 32	55.0 ± 7.0
WZS/581/02/15-20cm	15-20	66 ± 30	54.0 ± 8.0
WZS/581/02/20-25cm	20-25	57 ± 30	48.0 ± 6.0
WZS/581/02/25-30cm	25-30	41 ± 21	50.0 ± 8.0
WZS/581/02/30-35cm	30-35	70 ± 29	56.0 ± 6.0
WZS/581/02/35-40cm	35-40	28 ± 21	51.0 ± 6.0
WZS/581/02/40-45cm	40-45	68 ± 29	56.0 ± 5.0

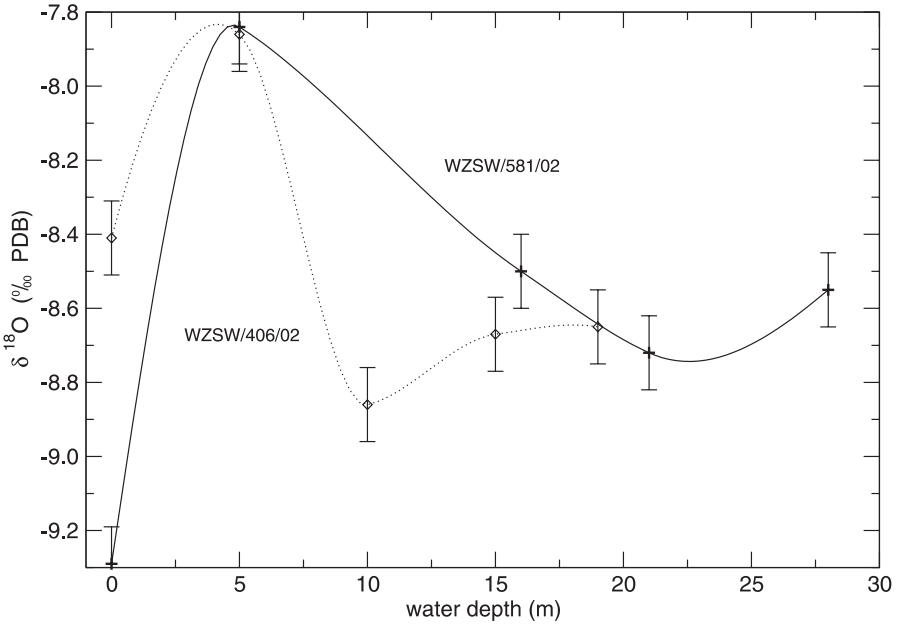

Fig 5. *Changes of oxygen stable isotopes composition in water profiles*

Table 5. *Results of ^{137}Cs activity determinations and laboratory uncertainties*

Sample name	Depth(cm)	^{137}Cs activity (Bq/kg)
Core	WZS/406/02	
WZS/406/02/0-5cm	0-5	14.2 ± 9.8
WZS/406/02/5-10cm	5-10	32 ± 11
WZS/406/02/10-15cm	10-15	21 ± 10
WZS/406/02/15-20cm	15-20	23 ± 10
WZS/406/02/20-25cm	20-25	33 ± 11
WZS/406/02/25-30cm	25-30	0.8 ± 9.6
WZS/406/02/30-35cm	30-35	1.9 ± 9.8
WZS/406/02/35-40cm	35-40	2.4 ± 9.9
WZS/406/02/40-45cm	40-45	1.6 ± 9.4
WZS/406/02/45-50cm	45-50	0 ± 10
WZS/406/02/50-55cm	50-55	0 ± 9.5
WZS/406/02/55-60cm	55-60	0 ± 9.8
Core	WSG/411/02	
WSG/411/02/0-5cm	0-5	0 ± 9.5
WSG/411/02/5-10cm	5-10	7 ± 9.8
WSG/411/02/10-15cm	10-15	0 ± 9.1
WSG/411/02/15-20cm	15-20	1 ± 10
WSG/411/02/20-25cm	20-25	7.2 ± 9.7
WSG/411/02/25-30cm	25-30	3.1 ± 9.4
WSG/411/02/30-35cm	30-35	8.9 ± 9.8
WSG/411/02/35-40cm	35-40	16.4 ± 9.4
WSG/411/02/40-45cm	40-45	23 ± 10
WSG/411/02/45-50cm	45-50	20.3 ± 9.8
WSG/411/02/50-55cm	50-55	0.0 ± 9.9
WSG/411/02/55-60cm	55-60	0 ± 10
WSG/411/02/60-65cm	60-65	2.4 ± 9.6
WSG/411/02/65-70cm	65-70	0 ± 10
Core	WSD/412/02	
WSD/412/02/0-10cm	0-10	128 ± 12
WSD/412/02/10-25cm	10-15	64 ± 12
WSD/412/02/25-35cm	25-35	40 ± 10
WSD/412/02/35-45cm	35-45	11.8 ± 9.2
WSD/412/02/45-55cm	45-55	14.2 ± 9.5
WSD/412/02/55-65cm	55-65	3.2 ± 9.3
WSD/412/02/65-75cm	65-75	1.2 ± 9.8
WSD/412/02/75-85cm	75-85	0.0 ± 9.5
WSD/412/02/85-95cm	85-95	1.1 ± 9.1
WSD/412/02/95-105cm	95-105	0 ± 10
Core	WZS/580/02	
WZS/580/02/0-5cm	0-5	34 ± 12
WZS/580/02/5-10cm	0-10	
WZS/580/02/10-15cm	10-15	
WZS/580/02/15-20cm	15-20	0.5 ± 9.4
WZS/580/02/20-25cm	20-25	0 ± 10
WZS/580/02/25-30cm	25-30	0 ± 10
WZS/580/02/30-35cm	30-35	0 ± 10
WZS/580/02/35-40cm	35-40	0 ± 10
Core	WZS/581/02	
WZS/581/02/0-5cm	0-5	41 ± 11
WZS/581/02/5-10cm	0-10	
WZS/581/02/10-15cm	10-15	2 ± 10
WZS/581/02/15-20cm	15-20	0 ± 10
WZS/581/02/20-25cm	20-25	1.9 ± 9.8
WZS/581/02/25-30cm	25-30	0.6 ± 9.6
WZS/581/02/30-35cm	30-35	2.1 ± 9.8
WZS/581/02/35-40cm	35-40	0 ± 10

Table 6. *Reservoir effect in sediment cores*

Core name	Fraction	q_0	T_r (yr)
WSD/412/02	organic	0.934 ± 0.017	1470 ±195
WZS/406/02	carbonate	0.780 ± 0.027	2000 ± 280
WSG/411/02	carbonate	0.819 ± 0.004	1600 ± 40

Table 7. *Radiocarbon age corrected for isotopic fractionation and reservoir effect and sedimentation rate calculated basing on radiocarbon age versus depth dependence*

Depth (cm)	T_{corr} (BP)	Sedimentation rate (mm/year)
WSD/412/02 core		
0-10	Modern	
10-25	Modern	
25-35	Modern	
35-45	65 ± 190	
45-55	325 ± 195	
55-65	355 ± 195	
65-75	805 ± 210	0.33 ± 0.04
75-85	1630 ± 205	
85-95	1975 ± 240	
95-105	1470 ± 195	
WZS/406/02 core		
0-5	5 ± 285	
5-10	30 ± 70	
10-15	55 ± 70	
15-20	Modern	
20-25	Modern	
25-30	Modern	
30-35	180 ± 70	
35-40	120 ± 85	
40-45	520 ± 70	0.24 ± 0.02
45-50	705 ± 90	
50-55	975 ± 60	
55-60	1075 ± 75	

Table 8. *Changes of oxygen stable isotopes ratios in the water profiles. Uncertainty is better or equal 0.1 ‰.*

Sample name	Depth (m)	$\delta^{18}O$ (‰, PDB)
Profile WZSW/406/02		
WZSW406/02/0m	0	-8.41
WZSW 406/02/5m	5	-7.86
WZSW 406/02/10m	10	-8.86
WZSW 406/02/15m	15	-8.67
WZSW 406/02/19m	19	-8.65
Profile WZSW/581/02		
WZSW/581/02/0m	0	-9.29
WZSW/581/02/5m	5	-7.84
WZSW/581/02/16m	16	-8.50
WZSW/581/02/21m	21	-8.72
WZSW/581/02/28m	28	-8.55

field and laboratory studies. The main conclusion of the results from all isotopic methods is that there is a strong change of the sedimentation rate in the 20th century. The sedimentation rate for deeper part of undisturbed cores is similar for two sites (two lakes - see **Table 2**) and equal to 0.24 mm/yr and 0.33 mm/yr. For the youngest part of the sediment these values increased drastically to 68 mm/year and 27.5 cm of sediment were deposited during the last 40 years as indicated by radiocarbon and radiocesium profiles (**Figure 2 A**). It is also important to conclude that for further lead and cesium investigation new coring and sampling methods must be applied.

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