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Markus J. Schwab, Piotr Lamparski,
Achim Brauer, Mirosław Błaszkiewicz (eds.)

2nd Annual ICLEA Workshop 2013

Dynamics of Climate and Landscape Evolution of Cultural Landscapes in the Northern Central European Lowlands since the Last Ice Age

Abstract Volume & Excursion Guide

Scientific Technical Report STR13/04

www.gfz-potsdam.de

HELMHOLTZ
GEMEINSCHAFT

Imprint

Helmholtz Centre Potsdam
GFZ German Research Centre for Geosciences

Telegrafenberg
D-14473 Potsdam

Printed in Potsdam, Germany
April 2013

ISSN 1610-0956

DOI: 10.2312/GFZ.b103-13047
URN: urn:nbn:de:kobv:b103-13047

This work is published in the GFZ series
Scientific Technical Report (STR)
and electronically available at GFZ website
www.gfz-potsdam.de > News > GFZ Publications

Virtual Institute of Integrated Climate and Landscape Evolution Analyses

-ICLEA-

A Virtual Institute within the Helmholtz Association

2nd Annual ICLEA Workshop 2013

Dynamics of Climate and Landscape Evolution of Cultural Landscapes in the Northern Central European Lowlands since the Last Ice Age

Abstract Volume & Excursion Guide

Edited by
Markus J. Schwab, Piotr Lamparski, Achim Brauer & Mirosław Błaszkiewicz

April 23 – 26, 2013 in Stara Kiszewa, Poland

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Chapter I: Program

Venue: Hotel Wrota Kaszub in Stara Kiszewa, voivodeship Pomerania, Poland

Address: ul. Konarzyńska 16, 83-430 Stara Kiszewa

Program Overview

Date	**Time**	**Topic**
Tuesday **April 23, 2013**	*15.00-16.00* *16.00-17.00* *17.00-18.00* *18.00*	*Check In* *Introduction talk* *Poster installation* *Ice breaker party*
Wednesday **April 24, 2013**	08.00-08.30	Address of welcome Introduction talks
Morning Session	8.30-13.00	Overview talk & Poster Presentation **WP1** Overview talk & Poster Presentation **WP2** Overview talk & Poster Presentation **WP3**
		Poster Session **WP1, WP2, WP3**
		Lunch
Afternoon Session	14.00-19.30	Overview talk **WP4** Overview talk & Poster Presentation **WP5**
	16.45-18.15	Poster Session **WP5**
	18.15-19.30	Open Poster Session **WP1 to WP5**
	19.00-20.00	Steering Committee Meeting & SAB
Evening	20.00	ICLEA Dinner
Thursday **April 25, 2013**	8.00-19.00	Excursion ICLEA - Investigation locations (Field wear highly recommended! To be aware of rain and mud!)
	11.00-15.00	Poster Presentation **WP4** & Poster Session **WP4** at Lake Czechowskie hotel & Lunch
		Continuation of the Excursion ICLEA - Investigation locations
	Evening	**Internal WP Discussion**
Friday **April 26, 2013**	8.00-10.00	Presentation of the WP Discussion (each WP 5 min. presentation + 5 min. Discussion) & Final Discussion
	10.00-13.00	Excursion ICLEA - Investigation Locations
	End 13.00	*Departure from the Field*

Detailed Program

Oral Presentation (O): 20 min. Talk & 10 min. Discussion

Poster Presentation (P): 5 min. power-point presentation by authors (3 slides; slide 1 overview whole poster, slide 2 & 3 main important facts/results) & general Discussion.
Poster Session (PS): For each Work Package will be a poster session in the poster hall with author presence at the poster, discussion.

Rooms: **Lecture hall "Lec" - Poster hall "Pos" - Hotel Czechowskie hall "Cze"**

Time in **bold** is a fix-time. Time in *cursive* is an orientation time.

Tuesday, April 23, 2013

Time	Topic	Room
15.00-16.00	**Arrival, Check in**	
16.00-17.00	**Opening** **Błaszkiewicz, Mirosław**: ***Introduction in the local Quaternary Geology*** *(talk in german)*	**Lec**
17.00-18.00	Poster installation	**Pos**
18.00-open end	**Ice Breaker Party with an typical Kaszubian Menu**	

Wednesday, April 24, 2013

Morning Session

Time	Topic	Room
08.00-08.10	**Błaszkiewicz, Mirosław** ***Address of Welcome***	**Lec**
08.10-08.20	**Brauer, Achim** *ICLEA - state of the art*	**Lec**
08.20-08.30	**Schwab, Markus** *ICLEA tools for virtual communication – External & Internal*	**Lec**
	WP1 Hydrological and climate data	
08.30-09.00	**(O) Blume, Theresa** *& Güntner, Andreas (GFZ): Hydrological Monitoring Network at Lake Hinnensee: Present State, First Results and Future Plans*	**Lec**
5 min	**(P) Wilke, Henriette** (GFZ) et al.: *Hydrogeological characterization of the Lake Hinnensee area by invasive and non-invasive methods*	**Lec**
5 min	**(P) Tecklenburg, Christina** (GFZ) et al.: *Spatial variability of groundwater-lake exchange and its controlling factors at Lake Hinnensee, Germany*	**Lec**
5 min	**(P) Dreibrodt, Janek** (GFZ) et al.: *Throughfall and stemflow monitoring in the Müritz-Nationalpark*	**Lec**
5 min	**(P) Simard, Sonia; Blume, Theresa** (GFZ) et al.: *Trees as Archives of Environmental Change - Linking Tree Ring Data (WP3) to Hydrological Processes (WP1)*	**Lec**

Time	Topic	Room
9.20-9.30	**Short discussion / questions WP1**	**Lec**
	WP2 Archive remote sensing data	
9.30-9.40	**(O) Itzerott, Sibylle** *Status of WP2*	**Lec**
5 min	**(P) Motagh, Mahdi** (GFZ) et al.: *Analysis of ground deformation in Neustrelitz region (Germany) using TerraSAR-X imagery*	**Lec**
5 min	**(P) Kleine, Iris** (GFZ): *Long-term monitoring of water surface area changes of groundwater lakes in Northeast Germany with remote sensing*	**Lec**
5 min	**(P) Itzerott, Sibylle** (GFZ) et al.: *Remote Sensing of landscape status in testsite Demmin*	**Lec**
9.55-10.05	**Short discussion / questions WP2**	**Lec**
10.05-10.30	***Coffee Break***	**Pos**
	WP3 Tree-ring data	
10.30-11.00	**(O) Wilmking, Martin** (UG) & **Heinrich, Ingo** (GFZ): *Status of WP3*	**Lec**
5 min	**(P) Simard, Sonia** (GFZ) et al.: *Oak vessels as potential hydroclimatic proxy*	**Lec**
5 min	**(P) Heinrich, Ingo** (GFZ) et al.: *Dendroclimatology of Scots pine in N-Poland*	**Lec**
5 min	**(P)** Thees, Barnim; **Buras, Allan** (UG) et al.: *What´s that noise? A new iterative statistical approach for the identification of linear relationships between noisy time series*	**Lec**
5 min	**(P) Burmester, Hannah** (UG) et al.: Disentangling the noise: Dendroecological investigations on the Darß peninsula	**Lec**
5 min	**(P) Scharnweber, Tobias** (UG) et al.: *Repeated flooding of a coastal mire-where's the elemental marker in oak tree-rings?*	**Lec**
5 min	**(P) Blome, Sandra** (UG) et al.: *Lakeshore alder (Alnus glutinosa L.) as sensitive recorders of lake level changes? First results from Drewitzer & Tiefer See*	**Lec**
11.30-11.40	**Short discussion / questions WP3**	**Lec**
11.40-12.00	***Coffee Break***	**Pos**
12.00-13.00	**Poster Session WP1, WP2 & WP3 authors in attendance**	**Pos**
13.00-14.00	***Lunch Break***	***Hotel***
	Afternoon Session	
	WP4 Lake sediment data	
14.00-14.30	**(O) Brauer, Achim** (GFZ), **Lorenz, Sebastian** (UG) **& Raab, Thomas** (BTU): The ICLEA lake records: climate, lake level, and human impact reconstruction	**Lec**

Time	Topic	Room
	WP5 Soil and geomorphologic data	
14.30-15.00	**(O) Raab, Thomas** *Work Package 5 - Status and research plan*	**Lec**
5 min	**(P) Dietze, Elisabeth** (GFZ) et al.: *Reconstructing past hydrological, sedimentological and geomorphological dynamics at Lake Fürstenseer See, northeast Germany - first results and new perspectives*	**Lec**
5 min	**(P) Kaiser, Knut** (GFZ) *Detection and attribution of lake-level variability in the Mecklenburg Lake District (northeast Germany) during the last decades*	**Lec**
5 min	**(P) Nicolay, Alexander** (BTU) et al.: *Mesolithic to Late Roman Iron Age / Migration Period landscape and soil development – results from archaeological and soil-geomorphological investigations nearby Jänschwalde, Lower Lusatia*	**Lec**
5 min	**(P) Takla, Melanie** (BTU) et al.: *An early industrial charcoal production area in Lower Lusatia (Germany) – a GIS based reconstruction of past landscapes with historical maps from the 18th and the 19th century*	**Lec**
15.20-15.40	***Coffee Break in Poster hall***	**Pos**
5 min	**(P) Hirsch, Florian** (BTU) et al.: *Late Quaternary soil genesis and geomorphodynamics in Wygonin*	**Lec**
5 min	**(P) Kordowski, Jarosław** (PAS) et al.: *Old Vistula River Lake in the Light of Cartographic, Sedimentological, Hydrological and Hydrochemical Investigations (Grudziądz Basin, North Central Poland)*	**Lec**
5 min	**(P) Badziai, Vitali** (NAS Belarus) *The evolution of the Dnieper River Valley near Orsha city during the Late Glacial and Holocene*	**Lec**
5 min	**(P) Brykała**, Dariusz (PAS) et al.: *Watermills operation on the Pomeranian rivers at the beginning of the 20th century*	**Lec**
5 min	**(P) Küster, Mathias;** Fülling, A.; Kaiser, K.; Ulrich, J. (UG) *Aeolian sands and buried soils in the Mecklenburg Lake District (Boek, NE Germany): Holocene land use history and pedo-geomorphic response*	**Lec**
16.05-16.15	**Short discussion / questions WP5** (& WP4)	**Lec**
16.15-16.45	***Coffee Break in Poster hall***	
16.45-18.15	**Poster Session WP5 authors in attendance**	**Pos**
18.15-19.30	**Open Poster Session for ALL WP**	**Pos**
19.00-20.00	Meeting of Steering Committee & Scientific Advisory Board SAB	Lec
	Evening	
20.00	**ICLEA Dinner**	**Hotel**

Thursday, April 25, 2013

Time	Topic	Room
7.00-8.00	***Breakfast***	
8.00	**Excursion**: **ICLEA - Investigations in N Poland, Landscape and Climate History** (Guides: Błaszkiewicz et al.) **(Field wear highly recommended! To be aware of rain and mud!)**	
11.00 - 12.20	**WP4 Lake sediment data** (Poster Presentation & Session at the **Lake Czechowskie hotel**)	
5 min	**(P) Ott, Florian** (GFZ) et al.: *Holocene and Late Glacial chronology for the varved sediments from Lake Czechowskie*	**Cze**
5 min	**(P) Slowinski, Michal, Zawiska, Izabela** (PAS) et al.: *Lake ecosystem response to rapid climate changes during lateglacial and early Holocene recorded in lake sediments (northern Poland)*	**Cze**
5 min	**(P) Obremska, Milena** (PAS) *Vegetation changes in the Czechowskie Lake area (Tuchola Forest) during the last 2000 years in the pollen record*	**Cze**
5 min	**(P) Lutyńska, Monika** (UPoznań) *Diatom record from Lake Czechowskie*	**Cze**
5 min	**(P) Tyszkowski, Sebastian** (PAS) et al.: *Preliminary analysis of land use changes over the last 200 years in the catchment of Lake Czechowskie*	**Cze**
5 min	**(P) Dräger, Nadine** (GFZ) et al.: *A new varved sediment record for NE Germany from Lake Tiefer See – Preliminary results from high resolution µ-XRF element scanning and microfacies analyses of Late Holocene lake sediments*	**Cze**
5 min	**(P) Kienel, Ulrike** (GFZ) et al.: *Lake-Tiefer-See monitoring: first results and perspectives*	**Cze**
5 min	**(P) Lorenz, Sebastian** (UG) et al.: *Palaeohydrological changes in Lake Tiefer See derived from littoral sediments and pollen data*	**Cze**
5 min	**(P) Theuerkauf, Martin** (UG) et al.: *Surface pollen samples from Lake Tiefer See*	**Cze**
5 min	**(P)** Romero Viana, Lidia (Uni Potsdam/GFZ), **Kienel, Ulrike** et al.: *The origin of long-chain alkenones in lakes and their paleoclimatic signal: a proxy calibration study from northeast Germany*	**Cze**
5 min	**(P) Küster, Mathias** (UG) et al.: *Water-level changes in lake basins and small depressions in NE Germany during the last 5000 years – a palaeohydrological model*	**Lec**
5 min	**(P) Börner, Andreas** (LUNG MV) et al.: *Distribution, stratigraphy und basin development of fossil lake basins near Dobbertin (Mecklenburg-Western Pomerania, NE-Germany)*	**Cze**
5 min	**(P) Wulf, Sabine** (GFZ) et al.: *Tephrochronological linking of lake sediment sequences from Germany and northern Poland*	**Cze**
10 min	**Short discussion / questions WP4**	**Cze**
12.30-13.30	**Lunch with a regional fish menu**	**Cze**

	Afternoon Session	
Time	Topic	Room
13.30-15.00	**Poster Session WP4 authors in attendance**	**Cze**
15.00-19.00	**Excursion**: **ICLEA - Investigations around Lake Czechowskie**	
19.30	**Dinner**	
21.00-23.00	**Internal WP Discussion and Coordination** Preparation of a ppt–Target Slide for **Each WP** (knowledge, WP-networking, proposal for common topics / WP structure, publications)	

Friday, April 26, 2013

Time	Topic	Room
7.00-8.00	***Breakfast and Checkout***	
8.00-8.50	**Each WP Speaker** *(5 min. Presentation + 5 min. Discussion)*: **Presentation Results Internal WP Discussion**	**Lec**
8.50-10.00	**Final Discussion and Conclusion**	**Lec**
10.00-13.00	**Excursion ICLEA - Investigation locations** (Guides: Mirosław Błaszkiewicz et al.)	
13.00	**End of the 2nd ICLEA workshop in the field**	

Chapter II: Poster Abstracts

WP1: Hydrological and climate data

Throughfall and stemflow monitoring in the Müritz-Nationalpark

Dreibrodt, Janek[1,*]; Germer, Sonja[2]; Morgner, Markus[1] & Blume, Theresa[1]

[1] Helmholtz-Centre Potsdam - GFZ German Research Centre for Geosciences, Section 5.4 Hydrology, Potsdam, Germany
[2] Leibniz-Institute for Agricultural Engineering Potsdam-Bornim (ATB), Department Bioengineering
* Corresponding author: janek.dreibrodt@gfz-potsdam.de

Rainfall partitioning in different forest stands, each with a certain tree species and age distribution, is a precondition to estimate evaporation, infiltration and eventually the water balance for the whole catchment.

For further discussion the experimental and technical design for throughfall and stemflow measurements as well as the selection of focus sites in the Müritz-Nationalpark based on forest stand parameters is presented. The experimental plots will be part of the integrated monitoring network in the TERENO-observatory “North-east German lowland” and have to be suitable for long-term monitoring.

Our study includes a detailed investigation of stemflow which is often only roughly estimated. It will be measured for selected trees individually. Having precise information about stemflow volume is important, because stemflow can result in preferential flow through the forest canopy and thus cause local rapid infiltration and groundwater recharge.

The plot size of 2000 m² for the throughfall measurements is bigger than usual and the measurements are thus likely to be more representative. The throughfall is collected in troughs with a length of 5 m. This spatial integrating measurement avoid biases caused by small-scale heterogeneities (e. g. due to drip points), that can occur in measurements with funnel-type collectors. 15 troughs, connected to groups of three, are randomly distributed on each plot. While only few studies focus on other deciduous trees than beech, our investigations will furthermore deal with oaks as frequently appearing deciduous trees in the catchment of Lake Hinnensee as well as with Scotch pine.

The long-term monitoring results will provide information about the potential impact of climatic changes on the hydrological conditions in different types of forests.

These ICLEA studies are supported by TERENO infrastructure of the Helmholtz Association.

Trees as Archives of Environmental Change - Linking Tree Ring Data to Hydrological Processes

Simard, Sonia [1,*] ,**Blume**, Theresa [2,*], Güntner, Andreas[2], Helle, Gerhard[1] & Heinrich, Ingo[1]

[1] Helmholtz-Centre Potsdam - GFZ German Research Centre for Geosciences, Section 5.2 Climate Dynamics and Landscape Evolution, Potsdam, Germany
[2] Helmholtz-Centre Potsdam - GFZ German Research Centre for Geosciences, Section 5.4 Hydrology, Potsdam, Germany
* Corresponding authors: simard@gfz-potsdam.de, blume@gfz-potsdam.de

Northeastern Germany (NE) is a region of high vulnerability with respect to climate change effects. A comprehensive hydrological study concentrating on groundwater and lake level records of the last 30 years has revealed that large areas in this region are characterized by decreasing groundwater recharge, leading to decreasing groundwater and lake levels of up to 5 m. Annual precipitation is rather low, varying between 550 and 650 mm/year, whereas a clear increase in average temperature has been observed since 1980 in the region. In spring 2012, an extensive monitoring site for tree growth and hydrological processes was established within the framework of the Virtual Institute for Integrated Climate and Landscape Evolution Analyses (ICLEA) project using TERENO infrastructures in the lowlands of NE-Germany.

This study is part of ongoing multi-disciplinary investigations on the impacts of hydrological changes, with decreasing water availability and increasing temperatures, on terrestrial systems. Dendrometers and sap flow sensors were installed on mature pine, beech and oak growing along transects that start at a lake shore and end on top of a nearby hill to evaluate the response of the species to varying water availability. In addition to wood growth, tree water status, soil moisture/matrix potential dynamics and ground water dynamics is also recorded. To understand the seasonal changes in water sources utilized by the trees and evaluate the sensitivity of the different species to changes in the precipitation and temperature regime, the course of oxygen isotope signals from water from these different sources during the vegetation period will be followed. By closely studying the relations between tree growth and hydrological processes we not only understand better the possible effects of climate changes on trees and the forest ecosystem, but we also explore the possibility of using tree rings as archives of past hydrological processes to gain information on past droughts in terms of frequency, duration and severity of water stress. The monitoring site will help us to understand how subsurface water dynamics, tree growth and transpiration are linked and to define the major environmental controls. We also present the conceptual framework of our future investigations at Lake Hinnensee, NE Germany.

Spatial variability of groundwater-lake exchange and its controlling factors at Lake Hinnensee, Germany

Tecklenburg, Christina[1,*]; Wilke, Henriette[1] & Blume; Theresa[1]

[1] Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences, Sect. 5.4 Hydrology, Potsdam, Germany
* Corresponding author: christina.tecklenburg@gfz-potsdam.de

Decreasing lake levels were observed in the last 20 years at several lakes in northeast Germany including Lake Hinnensee. The decrease in water level of this enclosed lake added up to 1.25 m from 1988 until 2006. In lakes without inflow or outflow, groundwater-lake exchange plays an important role in the entire lake water budget.

The aim of this study is to investigate the spatial variability of groundwater-lake interactions at Lake Hinnensee and to understand the controlling factors behind the observed patterns.

The exchange of the lake with the adjacent groundwater system is currently being investigated using piezometer nests and temperature as natural tracer. 20 piezometers were installed to monitor a section of the lake shore where main inflow is expected. Hydraulic gradients are measured continuously using pressure sensors as well as manually on a monthly basis. Temperature surveys were carried out in summer 2011 and 2012 and winter 2013. Thereby vertical temperature profiles to a depth of 0.4 m were measured in 10 m intervals at 0.5 m distance from the shoreline.

The measurements indicated that groundwater inflow is highly variable in space, varying from -12 to 165 L/m²/day and strongly decreasing with distance to shoreline. Three repetitions of the temperature survey showed that general exchange patterns are stable in time. Linkages between exchange rates and possible controls indicated that exchange patterns at Lake Hinnensee are controlled by the shoreline morphology, sediment heterogeneities and general groundwater flow paths.

These ICLEA studies are supported by TERENO infrastructure of the Helmholtz Association.

Hydrogeological characterization of the Lake Hinnensee area by invasive and non-invasive methods

Wilke, Henriette[1, *]; Thoss, Heiko[1]; Güntner, Andreas[1] & Blume, Theresa[1]

[1] Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences, Sect. 5.4 Hydrology, Potsdam, Germany
* Corresponding author: wilke@gfz-potsdam.de

Groundwater and lake levels have been decreasing at many locations in northeastern Germany for the last 30 years. However, the reasons for this decline are still unclear. Our investigation aims at a better understanding of this hydrogeological system: its structures, dynamics and control mechanisms. Focus area is the domain of Lake Hinnensee, which is located in a young moraine area in Mecklenburg-Vorpommern. The investigation area consists of the Pommeranian main terminal moraine in the north and the outwash plain in the south.

Currently, no detailed knowledge about subsurface structures, groundwater flow directions and dynamics is available for the lake Hinnensee region. However, as we are looking at a purely groundwater controlled lake system (no surface inflows or outflows), this information is essential for a better understanding of the ongoing processes. First field campaigns were carried out in 2012. The establishment of observation wells, a monitoring system and the investigation of subsurface characteristics with standard methods such as grain size analyses, permeameter tests on disturbed and undisturbed samples as well as pumping tests supplied important first insights. Due to the heterogeneity of the subsurface combined with limited possibilities to identify subsurface structures and boundaries through outcrop characterization, the application of geophysical approaches seems to be most promising for larger scale surveys. First electric resistivity tomography (ERT) surveys along different transects of up to 800 m length have been performed to detect the boundary between aquifer and aquiclude. In order to obtain extensive information on subsurface characteristics by a geophysical method, the creation of site-specific parameter relationships is necessary. Certain geophysical characteristics such as the specific electrical resistivity are controlled by porosity and water content. Hydraulic conductivity on the other hand, does not only depend on overall porosity but also on pore size distributions and is thus a difficult parameter to infer directly from geophysical measurements. However, it might be possible to deduce hydraulic conductivities by combining ERT and soil physical data sets for the project area. First results of the determined subsurface structures as well as an attempt for a geophysical interpolation of hydraulic conductivities are presented.

These ICLEA studies are supported by TERENO infrastructure of the Helmholtz Association.

WP2: Archive remote sensing data

Long-term monitoring of water surface area changes of groundwater lakes in Northeast Germany with remote sensing

Kleine, Iris[1,*]

[1] Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences, Sect. 1.4 Remote Sensing, Potsdam, Germany
[*] Corresponding author: ikleine@gfz-potsdam.de

The aim of this study is the long-term monitoring of water surface area changes of groundwater lakes in Mecklenburg-Vorpommern and Brandenburg, in Northeast Germany. The time series will illustrate water surface changes of 21 mostly groundwater influenced lakes during the last 50 years.

The detection of the water surface areas is performed via optical and SAR (synthetic aperture radar) imagery. An evaluation and comparison of both sensor types is necessary and scheduled for TerraSAR-X and RapidEye data. SAR can penetrate cloud coverage, enables a less weather-dependent monitoring and is daylight-independent. Optical imagery provides more possibilities for the classification of land and will be essential for additional land use change detection.

The analysis of the monitoring since 2007 will be performed based on the German TerraSAR-X satellite. TerraSAR-X StripMap data were acquired regularly in NE Germany, the most frequently monitored area is Neustrelitz and the adjacent “Großer Fürstenseer See”. 64 TerraSAR-X images (single polarization HH, descending path direction, resolution 3 m x 3 m) were acquired of this area between 2007 and 2011. The “Großer Fürstenseer See” is one of the key lakes as it has been monitored in detail in the past years. The extraction of the water surface areas for seasonal and annual change detection can be performed easily with threshold segmentation: smooth water surface areas appear dark in SAR imagery whereas the surroundings appear in a lighter grey. Problems in the monitoring could be submerged vegetation which reflects energy back to the sensor and the side-looking geometry of the sensors with local shadow effects at the shorelines.

For the comparison of different lakes, the analysis of volume changes will be achieved by relating the water surface areas with water level measurements and bathymetric data. The understanding of seasonal changes within one year is necessary for the conclusion of single shoreline results into the 50 year-long monitoring period. The long-term behavior of different lakes will be analyzed based on hydrological lake types (e.g. ground water influenced) and the big questions are: is there a common trend and which lakes react similarly?

These ICLEA studies are supported by TERENO infrastructure of the Helmholtz Association.

Analysis of ground deformation in Neustrelitz region (Germany) using TerraSAR-X imagery

Motagh, Mahdi[1,*]; Kleine, Iris[1] & Itzerott, Sibylle[1]

[1] Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences, Section 1.4 Remote Sensing, Potsdam, Germany
[*] Corresponding author: Motagh@gfz-potsdam.de

Interferometric Synthetic Aperture Radar (InSAR) has become a geodetic method of choice to assess ground deformation associated with natural and anthropogenic deformation. Our ability for precise deformation monitoring has further been enhanced using advanced InSAR techniques such as Permanent Scatterer Interferometry (PSI) and Small Baseline Subset (SBAS) techniques, which enable us to extract ground deformation with centimeter to millimeter accuracy by time-series analysis of phase of pixels which remain coherent in a stack of SAR images

In this paper, we investigate the capability of high-resolution TerraSAR-X imagery to assess ground deformation due to ground water level changes in Neustrelitz region in Germany. We use an archive of TerraSAR-X data covering 2008-2011 time interval, and present the first results obtained using the time-series technique of SBAS to map areas of ground deformation.

Remote Sensing of landscape status in testsite Demmin

Itzerott, Sibylle[1,*]; Spengler, Daniel[1]; Blasch, Gerald[1] & Hohmann, Christian[1]

[1]Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences, Section 1.4 Remote Sensing, Potsdam, Germany
*Corresponding author: itzerott@gfz-potsdam.de

The TERENO terrestrial observatories were established in order to facilitate the determination and quantification of environmental changes. The observatory Northeast German Lowland is operated by GFZ in different landscape types. Around the town Demmin in an agricultural used region (900 km²) the changes of land use and its influence on evaporation will be observed on a long-term basis (> 10 years).

Main goal is the modeling of evapotranspiration from multispectral and thermal remote sensing (RS) data with meteorological data on the regional scale and a daily level. This long time frame with extended data series of space and airborne remote sensing data allow to focus also on other subjects in landscape status such as soil moisture, soil pattern and vegetation dynamics from hyperspectral, thermal and radar data. In 2012 we started to focus on the monitoring and mapping of soil moisture variability in the vadose zone under agricultural land with different arable crops and soil texture types. In total 64 observation stations are planned (May 2013). Each station with 6 SPADE-sensors based on the frequency domain reflectometry method (FDR) provides continuous hourly measurements at 50 cm and 70 cm depths. In two campaigns in May and August 2012 we tested the potentials of remote sensing. In May simultaneous flights of airborne radar and hyperspectral systems over arable land with different crops in conjunction with ground truth surface and soil measurements are used to generate algorithms for soil moisture determination from both data systems. In August vegetation and arable soil characteristics in their diurnal variations were analyzed in visible (VIS), near infrared(NIR) and short wave infrared (SWIR) spectral range by using hyperspectral sensors and in thermal infrared (TIR) by thermal sensor. First results are shown.

These ICLEA studies are supported by TERENO infrastructure of the Helmholtz Association.

Visibility analysis in the landscape study using the Digital Photogrammetry 3D System DEPHOS – an example from Poland

Sarnowski, Łukasz[1,*]; **Brykała**, Dariusz[2] & Podgórski, Zbigniew[1]

[1] Nicolaus Copernicus University, Faculty of the Earth Sciences, Toruń, Poland
[2] Polish Academy of Sciences, Institute of Geography and Spatial Organization, Toruń, Poland
* Corresponding author: sarluk@doktorant.umk.pl

The results of the questionnaire surveys indicate that the most important factor increasing the attractiveness of tourist trails is the range and space of view. This demonstrates the importance and relevance of undertaking research to determine the range and space of view in the landscape. The primary goal determined in the present study is to develop and test a method for determining the range and space of view with the use of stereo-pairs of aerial photographs.

The area selected for testing the method is the north-eastern part of the Kujawsko-Pomorskie Voivodeship (Poland), characterised by a young glacial relief. The surface of the test area is 19.5 km². The area selected for analysis is attractive in terms of landscape; there are significant terrain elevation differences: the highest point is located at an altitude of 142 m, while the lowest at 74 m. The Brynica Valley runs across the selected area. The varied relief and a large percentage of the forested area meant that part of the study area is under protection, within the Górznieńsko-Lidzbarski Landscape Park and Brodnicki Landscape Park. In the selected area there are also four villages: Bartniczka, Radoszki, Zaborowo and Zdroje.

It was assumed that the GIS tools will be used for the analysis of the range of view, and the acquisition of the height of forests (natural factor limiting the range and space of view) and buildings (anthropogenic factor) will be based on the use of the photogrammetric station DEPHOS.

The first step was to determine the range of view on digital terrain models in the scale of 1:10,000. The test site for the analysis of the range of space of view was on the road between the villages Radoszki and Bartniczka. It was assumed that the observer is 1.7 m tall and that there are ideal weather conditions, i.e. not limiting visibility. The obtained maximum range of view was 13 km and the field of view stretched mainly in south and east directions (limited topographically).

The second phase of the work consisted in determining the height of forests and buildings. Stereo-pairs of aerial photographs were taken in 2009 with an analogue camera in a scale 1:26,000. The scale of the aerial photographs forced a two-meter measurement error tolerance of objects' height. After the internal, mutual and absolute orientation of the photos, the models were obtained on which the measurements were carried out. Fifty-four forested areas and 745 buildings were measured. The height measurements obtained for the photogrammetric station were tested in the terrain using a laser rangefinder. The measurement error ranged from -2.3 m to 2.2 m

The third stage of work was the uplift of forested areas and buildings on the numerical model by the values obtained from the analysis of aerial photographs. The results of the change of the range and space of view confirmed the need to take account of the land cover in this type of research. Forests limited field of view by up to 56% (predominantly in the southerly direction) compared to the area obtained only on the basis of the digital terrain model. Buildings reduced field of view by further 4%, mainly in the north and east direction.

WP3: Tree-ring data

Lakeshore alder (*Alnus glutinosa* L.) as sensitive recorders of lake level changes? First results from lake Drewitzer See & lakeTiefer See

Blome, Sandra[1]; **Scharnweber**, Tobias[1,*]; Wilmking, Martin[1] & Lorenz, Sebastian[2]

[1] Ernst-Moritz Arndt University-Greifswald, Institute of Botany and Landscape Ecology, Greifswald, Germany

[2] Ernst-Moritz Arndt University-Greifswald, Institute for Geography and Geology, Greifswald, Germany

* Corresponding author: tobias.scharnweber@uni-greifswald.de

Extending time series of lake levels into the past contributes to a better understanding of the highly variable lake levels during the last decades, one of the major goals of ICLEA. Alder (*Alnus glutinosa* L.) is a common tree species in wet lakeshore areas, able to grow at periodically flooded sites. Although not a common subject to dendrochronology, it has been shown that its ring patterns might reflect water level changes of adjacent rivers or lakes very well (Douda et al. 2009, Elferts et al. 2011). In our study we tested the potential of tree-rings of living alder as a proxy for lake level changes at two lakes which are ICLEA core research sites (Lake Drewitzer See - LDS, Lake Tiefer See - LTS). Lake-level changes are known for both lakes from historical maps as well as from sedimentological and gauging records.

At each lakeshore cores from ~20 living trees growing in wet alder carrs were taken. At LDS we additionally sampled along a chrono-sequence of three beach ridges with increasing distance to the recent lake shore. Cores from oaks (LTS) and pine (LDS) accomplish our study design. Although crossdating (the exact dating of every tree-ring) of the diffuse porous alder is very difficult, we successful developed species-specific chronologies for each lake area. The alder chronologies reach back to 1939 at LTS and to 1938 at LDS (replication >4 series).

We obtained significant negative correlations (r=-0.56) between detrended ring-widths of alder and previous year summer lake levels at LDS (common period 1982-2003). Contrary to this result and our expectations, at the much wetter alder carr at LTS growth was positively correlated (r=0.6, common period 1984-2011) to lake levels during the previous year of growth. Here the oak chronology shows exactly the opposite reaction with a negative influence (r=-0.52, common period 1984-2011) of high water levels during the previous year on current years radial growth.

These first results point at an important influence of site conditions on strength and even sign of correlations between lake levels and alder growth. Influence of other climate parameters is only weak, but, as water is hardly limiting, a positive reaction to warm summer temperatures is apparent from correlation analysis. Altogether our results are promising with regard to the proxy potential of alder ring patterns for lake level reconstructions.

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Disentangling the noise: Dendroecological investigations on the Darß peninsula

Burmester, Hannah[1]; Klos, Ruth[1]; Wendlandt, Wencke[1]; Wilmking, Martin[1] & **Buras**, Allan[1,*]

[1] University of Greifswald, Institute of Botany and Landscape Ecology, Germany
[*] Corresponding author: allan@buras.eu

Keywords: climate growth interactions, Scots pine, reliability of climate reconstructions

A central topic of ICLEA is reconstructing past environmental conditions. One important question to assure a meaningful reconstruction is, how different factors (e.g. soil developmental stages, distance to the groundwater, parasites, provenances) alter the relationships between proxy (in our case trees) and environmental variable (in our case climate). In November 2012 we obtained tree cores from 60 *Pinus sylvestris* in the national park 'Vorpommersche Boddenlandschaft'. All investigated trees grew under the same general climatic conditions. Each 20 trees were sampled on 300, 400, and 500 year old sand-dunes respectively to stratify our sample according to substrate development age with a maximum distance of 1 km between the sampled individuals. On the 300 year old dune we divided our sample to include 10 trees that had been used for resin production in the past and 10 control trees, to investigate effects of tree damage (representing calamities) on climate growth interactions. On the 400 year old dune, we sampled 10 trees growing at high groundwater levels (i.e. 1 m) and 10 trees growing on low groundwater levels (i.e. 3 m) to assess the different climate-growth relationships of trees with differing water availability. Finally, on the 500 year old dune, we sampled 10 trees, that have been planted in the 1950's and possibly belong to a different provenance of Scots Pine and compared those to 10 'native' trees. In this nested analysis, we aim to assess whether - and if so which of - the influencing factors has the strongest impact on climate-growth relationships.

Preliminary results indicate that the sensitivity and overall growth of Scots Pine differs among the different 'treatments'. Although several chronologies show a clear common signal, the amplitudes and mean values vary significantly. Thus, climate reconstructions will differ when these chronologies would be used, despite the fact that the trees on which the chronologies were built most likely have experienced the same climate.

Yet, it is unclear to which parameters the observed differences are related. It seems possible that either nutrient availability and/or water availability are the main determining factors, both of which significantly change as soils age (e.g. Scheffer and Schachtschabel, 1998). Further, local topographic conditions and competition likely play a role as well. We hope to clarify these important open questions, by additional element, density and pedological analyses as well as multivariate statistical techniques. Ideally, we would be able to find specific markers (either elements, isotopes or density), that allow for the identification of the relevant soil parameters. If succeeding, this would allow for significantly increasing the reliability of past climate reconstructions from tree-rings, as the models applied to archaeological wood could be adapted to the prevailing local conditions.

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Dendroclimatology of Scots pine in N-Poland

Heinrich, Ingo[1]; Knorr, Antje[1]; Beck, Wolfgang[2]; Wazny, Tomasz[3]; Heußner, Karl-Uwe[4]; Helle, Gerd[1]

[1] Helmholtz Centre Potsdam - German Research Centre for Geosciences GFZ, Section 5.2 Climate Dynamics and Landscape Evolution, *Potsdam Dendro Lab*, Potsdam, Germany
[2] Johann Heinrich von Thünen Institute, Forest Ecology and Forest Inventory, Eberswalde, Germany
[3] Nicolaus Copernicus University, Institute for the Study, Restoration and Conservation of Cultural Heritage, Torun, Poland
[4] Deutsches Archäologisches Institut, Berlin, Germany
* Corresponding author: heinrich@gfz-potsdam.de

As part of our ICLEA ambitions, Scots pine (*Pinus sylvestris*) was sampled in summer 2011 in the vicinity surrounding Lake Czechowskie, northern Poland. Our new well-replicated tree-ring width chronology of 200 year length was derived from old forest stands near Lake Czechowskie, which was then combined with two sets of regional Scots pine samples, collected from nearby archaeological sites and from forests in the region of Masuria. The chronology now extends back to the year 1084AD. The climate sensitivity of Scots pine at this new site has been evaluated and February temperatures have been reconstructed back to 1100AD. Furthermore, we have concentrated on analysing cell structures such as tracheid lumen for quantitative wood anatomy using the new GFZ confocal scanning laser microscope system. The results indicate even stronger correlations between cell structures and climate than were found between tree-ring widths and climate. In a next step we aim to combine the new Scots pine chronology with the sediment record from Lake Czechowskie to produce a multi-millennial high-resolution climate proxy record.

Repeated flooding of a coastal mire-where's the elemental marker in oak tree-rings?

Scharnweber, Tobias[1,*] & Wilmking, Martin[1]

[1] Ernst-Moritz Arndt University-Greifswald, Institute of Botany and Landscape Ecology, Greifswald, Germany
* Corresponding author: tobias.scharnweber@uni-greifswald.de

Oak stems preserved in bogs contributed strongly to the compilation of several thousand year long chronologies from different parts of Europe. However, the ecological inter-pretation of the inherent low and high frequency variations is still under debate and difficult to test as nearly no natural, undrained bog forests have remained in central Europe. Alternating phases of depressed and normal or high growth are mostly interpreted as caused by high and low water tables, thus wet and dry climate conditions respectively, as anoxic conditions in the soil (peat) restrict oak growth (e.g. Leuschner et al. 2002). The Anklamer Stadtbruch, a partly forested peatland at the Baltic seashore has been drained for several decades but was occasionally flooded. In November 1995 a severe storm-flood permanently damaged the dam. As a consequence, water tables near or above the surface led to area-wide forest die-back. Only at the somewhat higher areas some of the trees, mostly oaks, survived. This well-defined disturbance event offers the unique possibility to study the in-fluence of increasing soil water saturation on oak growth. For our study we sampled tree cores from 15 living and 15 dead oaks. Conventional tree ring analysis (early/latewood width) was combined with high-resolution µ-XRF analysis of elemental concentrations. We hypothesized that elements such as Chloride and Strontium, which are not heavily translocated within the wood (Burken et al. 2011) can serve as a marker for seawater in-fluence. Our results show a remarkably growth depression following the flooding event but for some trees also a recovery to "normal" growth rates after some years. Interestingly, although general growth patterns are similar between groups of surviving and dead trees, we found significant differences in mean sensitivity (a measure for year to year ring-width changes) and autocorrelation between the two groups in the decades *before* the flooding event. This may point at individual differences in adaptation potential rather than microsite influences determining survival or death. Elemental concentrations show poor common variations between individuals and interpretation is complicated by the fact that most of the elements show a sharp concentration difference between heart- and sapwood. We found no coherence between yearly Cl and Sr concentrations and documented flooding events of the mire. However, a general increase in Cl and non-nutrients, such as Ba and Sr concentrations, can be observed starting in the 1990´s, prior to the heartwood-sapwood boundary. This heartwood-sapwood border occurs around the year 2000 (in living trees) and may thus superimpose potential concentration increases due to the flooding event.

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Oak vessels as potential hydroclimatic proxy

Simard, Sonia[1,*]; Heinrich, Ingo[1]; Pohlmann, Silvio[1] & Helle, Gerd[1]

[1] Helmholtz-Centre Potsdam - German Research Centre for Geosciences GFZ, Section 5.2. Climate Dynamics and Landscape Evolution, Potsdam, Germany
* Corresponding author: simard@gfz-potsdam.de

A network of Terrestrial Environmental Observatories (TERENO) has been established in Germany in regions with the highest vulnerability with respect to climate change effects. At the regional level, long-term ecological, social, and economic impacts of global change are observed and explored. Recently, an extensive monitoring site for tree growth and water relations was established within the framework of the Virtual Institute for Integrated Climate and Landscape Evolution Analyses (ICLEA) project using TERENO infrastructures in the lowlands of NE-Germany. Here, we present some results from a research project part of ongoing investigations on impacts of hydrological changes, e.g. decreasing water availability and increasing temperatures, on terrestrial systems. The climate at the study site is characterized by a rather low annual precipitation varying between 550 and 650 mm/year. A comprehensive hydrological study concentrating on groundwater and lake levels records of the last 30 years in northeast Germany, has revealed that large areas are widely characterized by decreasing groundwater recharge, leading to decreasing groundwater and lake levels of up to 5 m. Both climate change and anthropogenic influences are likely to be important factors influencing terrestrial systems, and they take place at different spatial and temporal scales. The objective of the study was to explore the potential of different tree-ring parameters of Sessile oak (*Quercus petraea*) to gain information on hydrological changes at Lake Hinnensee. Chronologies of tree-ring width and earlywood vessels spanning 1901-2010 was developed from trees growing along the lakeshore and up the hill. The first results suggest that oak vessel size is sensitive to fluctuations of the lake/ground water level in those trees located at the lakeshore. A significant increase of the average vessel area was observed simultaneously to the decrease of the lake level observed since mid-80s. Oak vessels might be a good proxy to infer variations of ground water/lake level in the past although longer time series of lake level changes are required to validate our observations.

These ICLEA studies are supported by TERENO infrastructure of the Helmholtz Association.

What´s that noise? A new iterative statistical approach for the identification of linear relationships between noisy time series

Thees, Barnim[1]; **Buras**, Alan[2,*]; Jetschke, Gottfried[3]; Kutzbach, Lars[1]; Zorita, Eduardo[4] & Wilmking, Martin[2]

[1] University of Hamburg, Department of Pedology, Germany
[2] University of Greifswald, Institute of Botany and Landscape Ecology, Germany
[3] University of Jena, Department of Ecology, Germany
[4] Helmholtz-Zentrum Geesthacht, Institute for coastal research, Geesthacht Germany[*] Corresponding author: allan@buras.eu

Keywords: modeling, climate-reconstructions, statistical innovation

In dendrochronology, reconstructions of environmental conditions play a significant role (e.g. Fritts, 1976). Such reconstructions rely on the relationship between tree-ring features of woody plants and the environmental drivers that have determined these features. However, both of these variable types are noisy, i.e. the measured values (e.g. ring-width, temperature) only approximate the true values. On the one hand, ring-width is only a proxy for growth and not only determined by one specific environmental signal (e.g. temperature) but often blurred by other signals (e.g. precipitation). On the other hand, long records of environmental parameters are in general not available for the particular site at which the investigated trees/shrubs grew, this causing an additional noise in the relationship among measured ring-widths and available climate station data (e.g. Kutzbach et al., 2011).

If deriving models from such noisy data, Thees et al. (2009) and Kutzbach et al. (2011) could show (amongst others), that model slopes (the factor with which the one variable is multiplied to predict the other variable) in most cases are under- or overestimated – depending on the ratio of the variances of the respective variable errors. Despite these facts, many recent reconstructions are based on ordinary least squares regressions, which underestimate models slopes as soon as the predictor variable is noisy. This is because there yet is no statistical tool available to treat such noisy data sets in terms of modeling.

Here we propose a new iterative approach with which we are able to derive true model slopes between noisy time series as intended by several tests. This new approach has the potential to change our understanding of past climate variability, as the magnitude of amplitudes in reconstructed climate parameters may change significantly as soon as true slopes are used for reconstructions.

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WP4: Lake sediment data

Distribution, stratigraphy und basin development of fossil lake basins near Dobbertin (Mecklenburg-Western Pomerania, NE-Germany)

Börner, Andreas[1,*]; **Lorenz**, Sebastian[2] & Lampe, Reinhard[2]

[1] State authority for Environment, Nature protection and Geology Mecklenburg-Western Pomerania, Geological Survey, Güstrow, Germany
[2] Greifswald University, Institute of Geography and Geology, Greifswald, Germany
[*] Corresponding authors: andreas.boerner@lung.mv-regierung.de, sebastian.lorenz@uni-greifswald.de

In central Mecklenburg vast areas between the ice marginal zones of the Frankfurt and Pomeranian Phase were covered by glacio-lacustrine basins which were embedded in the outwash plains. With deglaciation of the Pomeranian Phase the basins north to the villages Dobbertin and Dobbin were part of a glaciofluvial river system in combination with ice-dammed lake basins. In 2011 the fossil lake-river-pattern was crossed by the NEL natural gas pipeline on a range of ca. 2.5 km with an up to 4 m deep pipeline ditch. The sediment sequence starts with glaciofluvial deposits once forming the surface. Therein numerous periglacial structures like meso-scale frost cracks up to large-scale frost wedge casts as well as soft sediment deformation structures like drop-soils and ball & pillow structures in fine grained and partly organic silts and glaciofluvial sands were observed. These multi-scale graviturbations are related to gravity-dominated load structures under cold periglacial conditions. During the Late Glacial initial organic and lacustrine sedimentation starts in shallow ponding mires evolving from buried dead ice sinks in the glaciofluvial sequence. A tree trunk could be recovered from a basal peat which probably has origin from the Bølling. Furthermore fossil gleyic soils occur. The following Late Glacial to Early Holocene lacustrine sedimentation is well preserved in several small sinks with diameters of 30-100 m, which are separated by glaciofluvial sediments. The lake sediments comprise calcareous and silicate gyttjas and reach a maximum thickness of 4 m. Several delta cones give evidence of (glacio-) fluvial influx probably from the River Mildenitz, which was draining southbound until the Younger Dryas-Preboreal transition (Lorenz 2008). The uppermost sequence is represented by a pattern of strongly decomposed Holocene peat and lacustrine sand.

A couple of profiles were sampled for palaeo-environmental reconstructions and ^{14}C/OSL datings. The investigations focus on (1) the chronology of lake-basin formation, (2) the palaeohydrological development of the lake basins as well as (3) their presumed connection to the transverse valley formation of River Mildenitz within the Pomeranian ice marginal zone (Lorenz 2008).

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A new varved sediment record for NE Germany from Lake Tiefer See – Preliminary results from high resolution µ-XRF element scanning and microfacies analyses of Late Holocene lake sediments

Dräger, Nadine[1,*]; Kienel, Ulrike[1]; Schedel, Robert[1]; Dulski, Peter[1]; Ott, Florian[1]; Lorenz Sebastian[2]; Theuerkauf, Martin[2] & Brauer Achim[1]

[1] Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences, Section 5.2. Climate Dynamics and Landscape Evolution, Potsdam, Germany
[2] Ernst-Moritz Arndt University-Greifswald, Institute for Geography and Geology, Greifswald, Germany
[*] Corresponding author: ndraeger@gfz-potsdam.de

Lake Tiefer See located in Mecklenburg-Vorpommern (NE Germany) has been selected for an integrated multi proxy study based on high resolution sediment analyses and monitoring, because of the ongoing deposition of annually laminated sediments (varves). The laminae deposited in the last ~90 years have been proven to be true varves by high resolution microfacies analysis (Kienel et al., in review). In September 2011, three continuous sediment profiles were recovered from the deepest part of the lake (~60 m depth). A preliminary chronology based on a first varve counting and radiocarbon dates yields an age of approximately 5000 yrs BP for the basal deposits of the 6.6 m composite sequence.

Combined microfacies analysis on petrographic thin sections and µ-XRF element core scanning has been applied to trace changes in the sediment composition and in the varve microfacies and to detect non-varved intervals. Six major lithological zones have been identified of which three are dominated by an excellent varve preservation (LZ I, LZ III and LZ V), while two zones (LZ II and LZ IV) are non- or poorly varved and correspond to higher Ti and K counts indicating increased detrital input by surface runoff and/or aeolian transport. According to the preliminary age model, the uppermost interval of increased detrital matter influx and decreased quality of varve preservation occurred during the time of the Little Ice Age suggesting more intense lake mixing and catchment erosion during this period.

Further investigations include detailed microfacies analyses, determination of TOC and carbonate content, isotope measurement of endogenic calcite and analyses of diatoms, pollen, macrofossils and cladocera. Furthermore, these data from the deepest part of the basin will be combined with cores from the littoral zone and the catchment to obtain a comprehensive view on the evolution of the lake basin. A new sequence of sediment cores will be taken in May 2013 in order to receive an entire sediment record back to the time when organic lacustrine sedimentation commenced in this basin. Ongoing sediment trap studies and monitoring of the water body will enable sophisticated interpretation of various climate proxies.

The overarching goal within the ICLEA objective is to synchronize the sediment record from Lake Tiefer See with its counterpart from Lake Czechowskie, located 378 km further east in northern Poland based on independent and high precision chronologies in order to investigate regional differences in lake responses to climatic and environmental changes along a W-E transect in the southern Baltic realm.

In this ICLEA study is TERENO infrastructure (WP4 “Varved lake sediments”) used.

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Kienel U., Dulski P., Ott F., Lorenz S., Brauer A. (in review): Recently induced anoxia leading to the preservation of seasonal laminae in two NE-German lakes. Journal of Paleolimnology

Lake-Tiefer-See monitoring: first results and perspectives

Kienel, Ulrike[1,*]; Brademann, Brian[1]; Dräger, Nadine[1]; Mingram, Jens[1]; Ott, Florian[1] & Brauer, Achim[1]

[1] Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences, Section 5.2 Climate Dynamics and Landscape Evolution, Potsdam, Germany
* Corresponding author: ukienel@gfz-potsdam.de

Lake Tiefer See in the Klocksin Lake Chain (ca. 120 km NNW of Berlin) has been selected as a lake monitoring site because of the ongoing deposition of annually laminated sediments. This offers the unique opportunity of a natural laboratory study of the link between the meteorological input signal and the sediment output with the objective to develop transfer functions for quantitative reconstructions.

Particulate matter deposition was trapped close to the bottom of Lake Tiefer See in 15-day periods from March to September 2012, accompanied by measurements of water column variables e.g., temperature, pH, and conductivity. Meterological data were acquired from the closest weather stations.

Dry matter deposition amounted to 1 g m^{-2} d^{-1} on average with the maximum deposition of 2.5 g m^{-2} d^{-1} in early June and a second maximum of 1.5 g m^{-2} d^{-1} from mid-August to mid-September. These maxima coincided with phytoplankton blooms in spring and late summer. The spring phytoplankton bloom (SpB) started at the end of April, when air temperature increased above 13°C and a thermocline (TCL) formed between 5 and 10 m water depth with 8°C warm water above the 4°C cold water in the hypolimnion. In this bloom, heavily silicified diatoms (*Aulacoseira subarctica*) were followed by diatoms with increased nutrient demand (*Stephanodiscus medius*). The co-occurrence of periphytic diatoms indicates redeposition of littoral material until the end of May. Synchronous with the SpB maximum in early June occured the maximum calcite precipitation, followed by the zooplankton maximum. The clear-water phase from mid-June to end July was followed by a strong summer bloom of *Fragilaria crotonensis*, indicating still sufficient nutrient availability that derived from wind-induced turbulences in June and July, which mixed the epilimnion down to a depth of 7 m. The synchronous increase of calcite in the trapped material related predominantly to a bloom of the calcifying *Phacotus lenticularis*. Both blooms declined in mid-September after a second, smaller zooplankton maximum. This decline related to the weakening of the TCL ($\Delta T < 4K$), its deepening below 15 m and subsequent decay as a combined response to decreasing air temperature below 15°C and wind speeds constantly above 2.5 m s^{-1}.

The oxygen isotope signature of the calcite precipitated during the spring bloom changed proportional to the average epilimnion temperature. Calculation of the oxygen isotope ratio of equilibrium precipitation results in coinciding values of -4.8 to -5 ‰ $\delta^{18}O_{carb}$ for this period, which indicates a possible inference of the June epilimnion temperature from the oxygen isotope ratio of the calcite.

Method adjustments after one year of monitoring experience included and will include the adjustment of the thermistor positions to capture the TCL development measured in 2012 (1-m intervals down to 15 m water depth) and a shortening of manual sampling/measuring intervals in the production season (April to October) from four to two weeks.

Surface cores planned to core in May 2013 will reveal the transfer of the 2012 trapping to seasonal laminae, which forms the basis for the development of transfer functions.

In this ICLEA study is TERENO infrastructure (WP4 “Varved lake sediments”) of the Helmholtz Association used.

Water-level changes in lake basins and small depressions in NE Germany during the last 5000 years – a palaeohydrological model

Küster, Mathias[1,*] & Fülling, Alexander[2]

[1] University of Greifswald, Institute of Geography and Geology, Germany
[2] Humboldt University of Berlin, Institute of Geography, Berlin, Germany
[*] Corresponding author: mathias.kuester@uni-greifswald.de

The Weichselian glacial belt of northeastern Germany is characterised by a heterogeneous river- (lake-) network. It comprises lakes of different size, shape and genesis - partly connected to the regional river-system and within closed basins of different dimension. During the last 20 years palaeohydrological research focused on reconstructing long term trends in Late Glacial and Holocene lake-level changes (e.g. KAISER et al. 2012).

About 800 years ago, humans started to change the hydrological system by constructing e.g. water mills and canals. Lake-level changes during the past 800 years were thus not only triggered by climatic changes or land use changes (forest opening) and related changes in groundwater formation, but also by human activity directly.

The aim of our research is to reconstruct Late Holocene lake- and groundwater-level changes within the Mecklenburg Lake District (NE Germany) in high temporal resolution. By integrating geoscientific (geomorphology, sedimentology), archaeological (finds) and historical data (maps, documents) and by studying lake basins connected to the river-network as well as lakes in isolated, hydrologically sensitive (small) basins, we aim to understand the causes (natural versus man-made) of Late Holocene lake-level fluctuations. The results are finally embedded in a palaeohydrological model.

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Palaeohydrological changes in Lake Tiefer See derived from littoral sediments and pollen data

Lorenz, Sebastian[1]; Theuerkauf, Martin[1]; Mellmann, Wenke[1] & Lampe, Reinhard[1]

[1] University of Greifswald, Institute of Geography and Geology, Greifswald, Germany
[*] Corresponding author: sebastian.lorenz@uni-greifswald.de

Lake Tiefer See is a deep lake (T_{max} = 64 m) with steep slopes. The presence of partly laminated sediments in the lake centre has initiated high resolution, multiproxy studies on climate-landscape interactions within ICLEA. Present study focuses on literal sediments as a record of past lake level changes.

Due to its steep slopes, literal deposition is largely limited to three bays with a typical aggradational fringe of peatlands, alder carrs, reed and shallow water with lake sediments. We drilled 14 cores along 3 transects (wind exposed and sheltered) and up to 7 m water depth. All cores reach the minerogenic basis, but most cores are only 2-3 m long. Cores were sampled in 5 cm intervals; analysis includes grain sizes, loss on ignition (TOC), CaCO3 (TIC), dry bulk density and pollen analysis; for peat samples additionally degree of decomposition (by spectral photometer).

The main transect in the SE bay includes three cores from peatlands (TS00, TS2 andTS3) and four cores from the 'open water' (TS1, TS4, TS5, TS6). No core shows a complete Late Glacial/Holocene record. In TS2 and TS3 sedimentation of lacustrine deposits starts in the Allerød period but switches to peat accumulation in the earliest Holocene, suggesting that the lake level during that time was about 5 m lower than today. Peat accumulation proceeds until ~ 3000 cal. BP. Several embedded black, more decomposed layers (partly with hiatuses) underline that the water level was fluctuating also during that period, but still well below the recent level. Continuous sedimentation of lacustrine deposits again starts ~3000 cal. BP, which is related to an increasing lake level. In TS4 and TS5 (in 3-5m water depth) we only find lacustrine deposits younger than ~ 4000-5000 cal. BP, in TS1 (in 1,5m water depth) only sediments younger than 3000 cal. BP, reflecting a step like lake level increase in the late Holocene. Older sediments possibly eroded during low lake levels prior to these dates.

Overall, the results suggest that the lake level of LTS fluctuated strongly over the Holocene, with mainly low levels in the early and mid Holocene and higher levels after ~3000 cal. BP. Maxima were possibly at least 1 m above the present water level, minima at least 5 m below.

Diatom record from Lake Czechowskie

Lutyńska, Monika[1,*]

[1] Adam Mickiewicz University Poznań, Department of Quaternary Geology and Palaeogeography, Institute of Geoecology and Geoinformation, Poznań, Poland
[*] Corresponding author: lutynska@amu.edu.pl

Diatoms belong to the most widespread groups of algae whose existence depends on the presence of water. They possess special bioindicative properties as to changes in salinity, pH, trophic status, and depth of water bodies (Blinn 1984, Patrick 1984, Schoemann et al. 1984, Cox 1991, Fritz et al. 1991, Round 1993).

Studies of fossil diatom floras provide a wealth of information about environmental conditions occurring in water bodies in the past. Variations in the species composition of the diatom flora are often used to reconstruct changes in the environmental conditions that occurred after the period of deglaciation.

In each sample about 500 diatom frustules were counted in order to estimate the relative abundance of individual taxa. The diatom analysis was conducted according to the method of Battarbee (1986). Ecological groups of diatoms based on pH and trophy were determined using OMNIDIA software (Version 4.2) (Lecointe et al. 1993) and then the resulting groups were distinguished according to Denys (1991/2) and Van Dam et al. (1994). The data were obtained from the literature (Krammer, Lange-Bertalot 1986, 1988, 1991a, 1991b, Denys 1991/2, Van Dam et al. 1994, Lange-Bertalot, Metzeltin 1996, Hofmann et al. 2011).

The total of 170 diatom taxa were identified in the sediment core. Most of them (150) were benthic species, while 20 were planktonic taxa. The diatom communities from the entire core were rich and very well preserved, however, broken valves were also recorded. A characteristic feature of the diatom communities is the dominance of planktonic species.

On the diagram the following planktonic diatoms dominated: *Cyclotella comensis, C. praetermissa, C. schumannii, Puncticolata radiosa*, there was also an increased number of *Fragilaria nanana* and *Stephanodiscus parvus* observed. With respect to pH generally Czechowskie Lake was circumneutral, later slightly alkalibiontic. At the depth of 55 cm more alkalibiontic. With respect to trophy Czechowskie was eutrophic all the time. At the depth of 55 cm increased hypereutrophic taxa.

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Vegetation changes in the Czechowskie Lake area (Tuchola Forest) during the last 2000 years in the pollen record.

Obremska, Milena[1,*]

[1]Polish Academy of Sciences, Research Centre in Warsaw, Institute of Geological Sciences, Warsaw, Poland
[*] Corresponding author: mobremska@twarda.pan.pl

Lake Czechowskie is located in the northern part of the Tuchola Forest region (Northern Poland). Lacustrine sediments of the Czechowskie Lake are laminated and has become a very valuable research material specially for the high resolution multi-proxy study. The samples for pollen analysis were taken based on the counted varves (every 5 years). The period of the last 2000 years is recorded in upper 5 m of the sediments sequence. Pollen analysis showed significantly deforestation during the Roman Period. The share of arboreal pollen distinctly decreased and many pollen grains of human indicators appeared (include cereals). Deterioration of the climatic conditions at the end of the Roman Period was the reason for migration of people. Decline of human activities was conducive to regeneration of mixed deciduous forest occurred during the Migration Period. At the time developed forest with a predominance of hornbeam (*Carpinus*). The pollen record shows that next deforestation started since Medieval Period. The most significant human impact on the plant communities is visible in the pollen diagrams since XV century. The development of settlements and agricultural activity is recorded by numerous presence of ruderal and cultivated plants pollen grains (*Artemisia, Rumex acetosa/acetosella , Plantago lanceolata, Centaurea cyanus, Cannabis, Fagopyrum, Triticum, Secale*). Significantly changed the composition of the forest. The most important component became pine (*Pinus sylvestris*).

Holocene and Late Glacial chronology for the varved sediments from Lake Czechowskie (Poland)

Ott, Florian[1,*]; Brauer, Achim[1]; Słowiński, Michał[1,2]; Dulski, Peter[1]; Plessen, Birgit[1]; Wulf, Sabine[1]; Obremska, Milena[3]; Lutyńska, Monika[4]; Noryskiewicz, Bozena[5]; Błaszkiewicz, Mirosław[2]

[1] Helmholtz-Centre Potsdam – GFZ German Research Centre for Geosciences, Section 5.2 Climate Dynamics and Landscape Evolution, Telegrafenberg, Potsdam, Germany
[2] Polish Academy of Sciences, Department of Geomorphology and Hydrology of Lowlands, Torun, Poland
[3] Polish Academy of Sciences, Institute of Geological Sciences, Research Centre in Twarda, Poland
[4] Adam Mickiewicz University, Department of Quaternary Geology and Palaeogeography, Institute of Quaternary Studies, Poznań, Poland
[5] Nicholas Copernicus University, Institute of Geography, Torun, Poland
[*] Corresponding author: florian.ott@gfz-potsdam.de

Annually laminated (varved) sediment records are essential for detailed palaeoclimate and environmental reconstructions as they function as a natural memory beyond instrumental datasets. In order to determine Holocene inter-annual and decadal-scale variability we investigated varved Lake Czechowskie (53°52' N/ 18°14' E, 108 m a.s.l.), northern Poland. During two coring campaigns in 2009 and 2012 we recovered several long and short cores with the longest core reaching 14.25 m. This sediment record can be a useful archive for palaeo climate and environmental reconstructions if a robust and reliable time scale is established.

Here we present the chronology for the Czechowskie lake sediment reaching back to ca. 14 ky BP based on AMS ^{14}C dating of 30 samples (27 terrestrial macro remains, three bulk sediment samples). New advances in Bayesian age modeling helped to identify samples either too old or too young caused by redeposition or low C content, respectively. The established age model is used to date sudden sedimentological changes which will be later used for a comprehensive understanding of landscape and climate change at the lake and its vicinity.

Varve counting has been applied for the last 4000 years were the chronology is confirmed by calibrated radiocarbon ages and ^{137}Cs activity measurements for the last 50 years. The good agreement between the varve counts and the modeled age based on radiocarbon dates proves the robust age control for the sediment profile. As the entire profile is well (88 %) or poorly (5 %) annually laminated, varve counting will be continued to gain a precise and robust chronology in addition to the preliminary AMS ^{14}C derived age model.

Based on lithological correlation with the neighboring palaeolake record (Trzechowskie mire) we assume an Allerød age for the onset of organic lake sedimentation. The finding of the Laacher See Tephra as a so-called crypto-tephra from this palaeolake record makes it likely to trace this volcanic ash in the lake record as well. This would provide an ideal isochrones for correlation of the Lake Czechowskie record with other varved lake sediments in Western Europe and even the Alps.

The overarching goal within the ICLEA objectives is to synchronize the sediment record from Lake Czechowskie with its counterpart from Lake Tiefer See, located 378 km further west in NE Germany based on independent and high precision chronologies in order to investigate regional differences in lake responses to climatic and environmental changes along a W-E transect in the southern Baltic realm.

This ICLEA study is co-financed by the Helmholtz Association climate initiative REKLIM topic 8 "Rapid climate change derived from proxy data".

The origin of Long-Chain Alkenones in lakes and their paleoclimatic signal: A proxy calibration study from Northeast Germany

Romero-Viana, Lidia[1,2,*]; **Kienel**, Ulrike[2], Schwarte, Sandra[3]; Tiedemann, Ralph[3]; Brauer, Achim[2] & Sachse, Dirk[1]

[1] University of Potsdam, Institute of Earth and Environmental Science, Potsdam, Germany
[2] Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences, Section 5.2 Climate Dynamics and Landscape Evolution, Potsdam Germany
[3] University of Potsdam, Institute of Biochemistry and Biology, Evolutionary Biology, Potsdam, Germany.
* Corresponding author: lidia.romero@geo.uni-potsdam.de

Long-chain alkenones (LCA) have become a standard proxy for the reconstruction of past sea surface temperatures in marine environments. This is based on the observation of a linear relationship between the degree of unsaturation (expressed as the Uk'37 index) and water temperature. Increasingly, LCAs are reported from lakes around the world ranging from hypersaline to freshwater conditions and have been used as a lacustrine paleothermometer. However, the degree of unsaturation of LCAs in lakes as a proxy of temperature is still associated with large uncertainties: lacustrine LCA producing algae are different and more diverse than marine species and the Uk'37 relationship with temperature is characterized by species-specific sensitivities.

In order to clarify lacustrine LCA sources and evaluate their sensitivity to temperature we designed a study of six LCA containing lakes in Northeast Germany (Zink et al 2001). In 2012 a two-year monitoring program was set up in Lake Tiefer See, where we identified LCAs in surface sediments for the first time. Here, monthly particulate organic material, water and sediment trap samples were collected to compare the production of alkenones to changes in the physical and chemical condition of the lake water. In order to constrain the potential source organism, we used DNA fingerprinting based on 18S r RNA gene analysis. In addition to the spatial calibration we compared LCA concentrations and the Uk'37 ratio in the annually laminated sediments of Lake Tiefer See covering the last 90 years to the instrumental temperature record from the region. We observed an increase in alkenone concentrations over the last three decades coinciding with an increase in the regional mean temperatures. The results of our work point out LCA as a highly sensitive paleotemperature indicator and contribute to the development of a new global proxy in lake sediments.

This ICLEA study is co-financed by the Helmholtz Association climate initiative REKLIM topic 8 "Rapid climate change derived from proxy data".

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Lake ecosystem response to rapid climate changes during lateglacial and early Holocene recorded in lake sediments (northern Poland)

Słowiński, Michał[1,2,*]; **Zawiska**, Izabela[3]; Ott, Florian[1]; Noryśkiewicz, Agnieszka Maria[4]; Apolinarska, Karina[5]; Lutyńska, Monika[6]; Michczyńska, Danuta Joanna[7]; Brauer, Achim[1]; Wulf, Sabine[1]; Skubała, Piotr[8] & Błaszkiewicz, Mirosław[2]

[1] Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences, Section 5.2 Climate Dynamics and Landscape Evolution, Potsdam, Germany
[2] Polish Academy of Sciences, Department of Environmental Resources and Geohazard, Institute of Geography, Toruń, Poland
[3] Polish Academy of Sciences, Department of Geoecology and Climatology, Institute of Geography and Spatial Organization, Warszawa, Poland
[4] Nicholas Copernicus University, Institute of Archaeology, Toruń, Poland
[5] Adam Mickiewicz University, Institute of Geology, Poznań, Poland
[6] Adam Mickiewicz University, Department of Geology and Quaternary Paleogeography, Poznań, Poland
[7] Silesian University of Technology, GADAM Centre of Excellence, Department of Radioisotopes, Institute of Physics, Gliwice, Poland
[8] University of Silesia, Department of Ecology, Katowice, Poland.
* Corresponding authors: michal@geopan.torun.pl, michal.slowinski@gfz-potsdam.de & ikrajewska@twarda.pan.pl

Climate was the main factor which controlled environment changes during Late Glacial Period. Permafrost thawing, vegetation development, ground water circulation and many other were controlled by it and in the same time had indirect influence on lake ecosystems. These environmental changes are very well recorded in lake sediments and thus can be reconstructed applying a multi-proxy approach.

Here, we present the results from the Trzechowskie paleolake, located in the northern Polish lowlands (eastern part of the Pomeranian Lakeland). The site is situated on the outwash plain of the Wda River, which was formed during the Pomeranian phase of the Vistulian glaciation ca 16,000 14C yrs BP. The depression of the Trzechowskie lake basin formed after melting of a buried ice block during the Bølling (13903±170 cal yrs BP).

In order to reconstruct environmental changes in the Trzechowskie paleolake and its catchment we chose biotic proxies (macrofossils, pollen, Cladocera, diatoms, Oribatidae mite) and geochemical proxies (18O, 13C, loss-on-ignition (LOI), CaCO3 content). In addition, we carried out µ-XRF element core scanning. The core chronology was established by means of biostratigraphy, AMS14C dating of plant macro remains, varve counting in laminated intervals and the late Allerød Laacher See Tephra isochrone. We compared the data from the Trzechowskie paleolake with the Meerfelder Maar and Rehwiese lake records using the Laacher See Tephra and with the Gościąż and Perespilno lakes using the pollen records.

In the first stage of our project we analysed samples with 2cm resolution. Our results showed that biogenic accumulation in the lake started during the warm period in late glacial. Development of coniferous forest during the Allerød with dominance of *Pinus sylvestris* lead to leaching of carbonates from the catchment due to low pH increasing the flux of Ca ions into the lake. In consequence calcite precipitating in the lake increased as evidences by increasing CaCO3 contents. Both biotic and physical proxies clearly reflect the rapid decrease in productivity at the onset of the Younger Dryas.

In second stage of our project we decided to investigate in details warmer period of late glacial and the transition to Younger Dryas. For biotic proxies we took samples with 0,5cm resolution.

Surface pollen samples from Lake Tiefer See

Theuerkauf, Martin[1] & Kienel, Ulrike[2]

[1] University of Greifswald, Institute of Geography and Geology, Greifswald, Germany
[2] Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences, Section 5.2 Climate Dynamics and Landscape Evolution, Potsdam, Germany
* Corresponding author: martin.theuerkauf@uni-greifswald.de

Lake levels not only change in response to climate variables but also in response to vegetation changes in the catchment area. Coniferous trees, for example, evaporate more water than deciduous trees or open vegetation and thus reduce groundwater formation. Interpreting past lake level changes thus needs to consider vegetation changes as a potentially confounding factor.

Pollen is the best proxy available to reconstruct past terrestrial vegetations. However, interpreting the pollen record is hampered by the facts that plant species differ in pollen productivity and pollen dispersal properties so that they may be over- or underrepresented in the pollen record. Approaches to correct these biases are available, but rely on a number of parameters, including pollen productivity. Measuring pollen productivity directly is virtually impossible, it is instead estimated by comparing surface pollen samples from lake sediments, moss polsters or pollen traps with present day plant abundances in the surroundings of these sites.

Pollen productivity is not constant but influenced by climate, stand structure and, namely for open vegetation, by land use practices. In arable fields, for example, the introduction of herbicides in the mid-20th century has reduced the abundance of weeds, including wild grasses as the main pollen producer in this field. In grassland, the transition from hay-making to bale silage has possibly reduced flowering activity and thus pollen production of grasses. The present day pollen productivity of open vegetation, including arable land and grasslands, is thus assumingly lower than in was in the past.

To quantify these effects, we study changes in pollen deposition during the last ~80 years using laminated lake sequences. Over that period, Lake Tiefer See (Klocksin) shows a marked increase in tree pollen deposition (with the exception of ULMUS), possibly representing re-forestation following both world-wars. Most herbal pollen instead decline. PLANTAGO LANCEOLATA and RUMEX ACETOSELLA, both representing weeds in arable fields, strongly decline in the 1960. This decline possibly represents the beginning widespread application of herbicides. Grass pollen deposition only declines in the early 1990th, possibly reflecting marked shifts in land use practices after the political changes. SINAPIS is the only herbal pollen type that increases during the study period, possibly reflecting the increasing cultivation of oilseed rape. These results will be verified using further sites.

Tephrochronological linking of lake sediment sequences from Germany and northern Poland

Wulf, Sabine[1,*]; Ott, Florian[1], Słowiński, Michał[1,2]; Dräger, Nadine[1]; Dulski, Peter[1]; Noryśkiewicz, Agnieszka M.[3]; Neugebauer, Ina[1]; Puertas, Celia Martin[1]; Błaszkiewicz, Mirosław[2] & Brauer, Achim[1]

[1] Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences, Section 5.2 Climate Dynamics and Landscape Evolution, Potsdam, Germany
[2] Polish Academy of Sciences, Institute of Geography and Spatial Organization, Department of Environmental Resources and Geohazards, Toruń, Poland
[3] Nicolaus Copernicus University Torun, Institute of Archaeology, Toruń, Poland
[*] Corresponding author: swulf@gfz-potsdam.de

Volcanic ash (tephra) analysis is a useful tool for independently dating and synchronizing palaeoclimate records from different environments (i.e., lakes, oceans, glaciers). Examples are given from Late Glacial and Holocene sedimentary archives in the northern central European lowlands, which exhibit widespread tephras from Icelandic volcanoes and the Eifel Volcanic Field. The latter erupted the phonolitic Late Allerød Laacher See Tephra (LST; 12,880 ± 40 varve yr BP; Brauer et al., 1999), which is the most widespread and best dated tephra marker in this region. It is documented as a visible layer of 0.5 cm to 3 cm thickness in many lacustrine sites in north-eastern Germany. Recently, tephra studies of partly varved sediments of Trzechowskie palaeolake in central Northern Poland lead to the finding of the LST cryptotephra for the first time in a very distal site ca. 840 km ENE from its volcanic source. The detection of the low number of volcanic glass shards (ca. 10 shards/cm^3) involved a new combined technique of biostratigraphical constraints, high-resolution µ-XRF core scanning and areal mapping of impregnated sediment blocks as well as systematic sampling of potential tephra-bearing sediments. The LST finding in Trzechowskie will enable direct synchronization with other high-resolution archives in north-central Europe (i.e., Lake Meerfelder Maar, Rehwiese palaeolake) to investigate regional variations of environmental responses at the onset of the Younger Dryas along a ca. 900 km SW-NE transect through northern central Europe.

These ICLEA studies are a co-financed by the climate initiative REKLIM Topic 8 “Abrupt climate change derived from proxy data” of the Helmholtz Association and the INTIMATE EU-COST Action ES0907.

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WP5 Soil and Geomorphological Data

The evolution of the Dnieper River Valley near Orsha City during the Late Glacial and Holocene

Badziai, Vitali[1,*]

[1] National Academy of Sciences of Belarus, Institute for Nature Management, Minsk, Belarus
[*] Corresponding author: bodv@rambler.ru

The structure of quaternary sediments at the valley of Dnieper River in a considerable extent is defined by structure of the pre-quaternary surface. This surface has deep drainage line (channel) and wide watersheds. Huge ancient channel is located under present day Orshica River valley and under Dnieper River valley (to the west from Orsha City). It has about 50-60 m t.a. Ancient channel has been used by glacier to movements and drainage of melt waters. Channel is filled by fluvioglacial sediments (with gray sands, gravels, varved clays) and moraine all quaternary ages. It can be supplied that ancient channel is connected with ancient drainage line from West Dvina basin. It described at the Chashnickaya lowland. Under the present day the valley of Dnieper River to the east from Orsha City ancient (pre-quaternary) watershed had been placed. It has about 130-150 m t.a.

There are two river erosion terraces (13 m and 10 m) and floodplain at the valley of Dnieper River. Near Orsha city 13 m terrace (second) of the Dnieper River is placed along the maximal stage of the Late Glacial. This border of the Late Glacial is underlining by sanders and loesslike deposits. Alluvium of the second terrace is interfacing genetically and morphologically with sanders near Orsha City. About 200 km to the south from the maximal stage of the Late Glacial alluvium of the second terrace has about 45 000 B.P. Retreating of the Late Glacial had defined the development of the near glacial lakes to the north and to the east (near Smolensk City) from Orsha City. Melt water drainage from north occurred through the valley of Orshica River and further to the Dnieper River valley. From the east drainage occurred into the Dnieper River valley. Increased volume of the water had defined the increasing of the erosion at the Dnieper River valley. The break at the erosion had brought to shaping of the first terrace (10 m) near Orsha City. Alluvium of the first terrace are overlaying the sediment about 17 150 B.P. Subsequently near glacial lakes were increased at their sizes. Lowest point of the watershed was placed at the Dnieper River valley near Kopys city (to the west-south from Orsha city). At that place basic drainage of melt waters into the Dnieper River valley had been occurred to the south. Huge volume of water had defined the cutting of the all quaternary sediments by Dnieper River at the deep about 50-60 m. Second place of drainage was Berezina River valley. Hereinafter when glacier was outside Belarus erosion base level at the basin of West Dvina had lowed and capitation some rivers from the Dnieper River basin had occurred. That had defined the decreasing arriving water from the Orshica River at the valley of Dnieper River and concentration the Dnieper River at the east from Orsha City.

Shaping of the valley of Dnieper River in a grate degree was defined by development of the Late Glaciation. At the area of Orsha City melt waters flow to the near glacier lakes and from their through the valleys of Orshica River (ancient channel) to the valley of Dnieper River. Probably that valley of the Dnieper River had been absent until the Late Glaciation to the east from Orsha City. The valley of Dnieper River continued to the North from Orsha City. After end of the drainage of melt water the Dnieper River was changed from braided channel to the low meandering channel. The flood plain accumulating had started at the beginning of the Holocene.

Evolution of canal systems linking the Vistula, Dnieper and Neman basins

Brykała, Dariusz[1,*] & Badziai Vitali[2]

[1] Polish Academy of Sciences, Institute of Geography and Spatial Organization, Toruń, Poland
[2] National Academy of Sciences of Belarus, Institute for Nature Management, Minsk, Belarus
[*] Corresponding author: darek@geopan.torun.pl

The aim of this study is to reconstruct landscape changes in the Polesie Region - one of the largest European swampy areas (Belarus), as a result of the creation and operation of a network of canals.

From the 16th century efforts were undertaken to connect the Polish areas located in the drainage basins of the Black Sea and Baltic Sea with canals. Already in 1631 the Polish Sejm (parliament) approved the project to build a canal linking the River Berezina (Dnieper basin) with the River Neris (Neman basin). However, the complicated political and economic situation of the country did not allow doing this.

Only in the second half of the 18th c. hetman Ogiński financed the construction of a canal linking the Dnieper and Neman basins. The canal connecting the River Szczara (Neman basin) with the River Jasiołda (Pripyat basin) was named after its creator – the Ogiński Canal.

At the same time the construction of the Królewski (*Royal*) Canal linking the River Muchavets (Vistula basin) and the River Pina (Pripyat basin) was under way. The construction of the canal was completed in 1783. The winding channels of the Pina and Muchavets were straightened, and the numerous canals feeding the waterway system drained vast area of marshes and wetlands of the Polesia Region. The last element that connects the catchments of the Vistula and Neman is the Augustów Canal built in the years 1825-1839 (linking the catchments of the Biebrza and Neman).

Numerous changes in political boundaries in the watershed area between the Black Sea and the Baltic Sea drainage basins caused the destruction of the hydraulic structures. All the analysed canals were completely destroyed during the two world wars. In the last 200 years the amount and type of locks and weirs has changed. For example, there were no weirs on the Royal Canal in the late 18th c., in the middle of the 19th c. there were 22 such structures, while now that number has gone down to 10.

All canals were created for economic reasons, i.e. of the need for floating of timber and food. Currently, in most cases they are tourist attractions only. Only the Royal Canal, known as the Dnieper-Bug Canal, plays a very important transportation role in the economy of Belarus.

These ICLEA studies are a co-contribution to the intergovernmental agreement on scientific cooperation between Poland and Belarus in years 2011-2013: No. 13.

Watermills operation on the Pomeranian rivers at the beginning of the 20th century

Brykała, Dariusz[1,*]; Chrzanowski, Kamil[2] & Czarnecki, Piotr[2]

[1] Polish Academy of Sciences, Institute of Geography and Spatial Organization, Toruń, Poland
[2] Nicolaus Copernicus University, Faculty of the Earth Sciences, Toruń, Poland
* Corresponding author: darek@geopan.torun.pl

As part of the research on the reconstruction of the hydrotechnical development of the Polish rivers, in 2011-2013 two master's theses were prepared at the Copernicus University in Toruń. The papers concerned the rivers of the Pomeranian and West Pomeranian Voivodeships (northern Poland).

The main source of the research studies were old maps made for the area in question at the turn of the 18th and 19th c. (Karte von Ost-Preussen nebst Preussisch Litthauen und West-Preussen nebst dem Netzdistrict on the scale of 1:150,000 and Topographisch-militairischer Atlas von den Herzogthümern Pommern on the scale of 1:180,000) as well as at the beginning of the 20th c. (so called Maestischblatt on the scale of 1:25,000). In summer 2012 a field inventory of the remains of watermill impoundments in the selected river basins was carried out.

There were 455 sheets of Maestischblatt analysed. A database of 892 objects using energy of flowing water was collected in the GIS software. A vast majority of buildings are old watermills based on structures impounding watercourses. On the watercourse up the damming structure small water impounding reservoirs (mill ponds) were created. The volume of the reservoir retention on the rivers of Pomerania was estimated to have been about 5 million cbm of water.

The spatial distribution of watermills in the area showed a big diversity. In addition to watercourses with a significant number of watermills (e.g. Radunia – had 16 mills, Parsęta – 12, Tywa – 12, Wierzyca – 10, Rurzyca – 10, Struga Oliwska - 9), there were large areas not used for hydropower production. This depended on land use in the surrounding area as well as the longitudinal profile of watercourses.

Before the industrial revolution the use of hydropower on the rivers of Pomerania was 1.2 times higher than at the beginning of the 20th c (at the beginning of the 19th c. there were 1,081 watermills within analysed area). Currently, on these rivers only about 150 small hydropower plants operate (13% of the objects existing 200 years ago).

In addition to the above, in the Pomerania Region 19 locations of old watermills on the watercourses flowing from the lakes were identified. In many cases, their hydro-technical mechanisms impounded lakes since the Middle Ages. Lake impoundments ranged from 0.5 to 1.5 m. In most cases, these lakes are no longer under the influence of damming structures.

These ICLEA studies are co-funded by the National Science Centre (NCN - grant: UMO-2011/03/D/HS3/ 03631).

Reconstructing past hydrological, sedimentological and geomorphological dynamics at Lake Fürstenseer See, northeast Germany – first results and new perspectives

Dietze, Elisabeth[1,*]; Kaiser, Knut[4]; Küster, Mathias[2]; Graventein, Hagen[4]; Fülling, Alexander[3]; Theuerkauf, Martin[2]; Brademann, Brian[1]; Dulski, Peter[1]; Kienel, Ulrike[1]; Koch, Paul[4]; Ott, Florian[1] & Brauer, Achim[1]

[1] Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences, Section 5.2 Climate Dynamics and Landscape Evolution, Potsdam, Germany
[2] University of Greifswald, Institute of Geography and Geology, Greifswald, Germany
[3] Humboldt University of Berlin, Institute of Geography, Berlin, Germany
[4] Helmholtz-Centre Potsdam - GFZ German Research Centre for Geosciences, wVB Scientific Executive Board, Germany
* Corresponding author: edietze@gfz-potsdam.de

Deciphering the main processes contributing to lake and landscape evolution in the young morainic area of the northern central European lowlands on different temporal scales is one of the main targets of the Virtual Institute of Integrated Climate and Landscape Evolution Analysis (ICLEA). In the context of future climatic changes especially the hydrological system is a vulnerable landscape component that showed considerably large changes in the recent past, e.g. in the water levels of ground-water-fed, closed lake systems (Germer et al., 2011; Kaiser et al., 2012). To get an idea about the long-term dynamics of regional lake and groundwater levels geomorphological and sedimentological archives are currently under investigation at Lake Fürstenseer See (53°19'N, 13°12'E, c. 63 m a.s.l. in 2011). The lake has a maximum water depth c. 24.5 m in the southeast, c. 2 km² lake area and a surficial/subsurficial catchment area of c. 40 km²/20 km² including other lakes and peatlands that are naturally or anthropogenically connected to Lake Fürstenseer See.

Littoral landforms, a multitude of pedosedimentary sequences from supra-littoral sites and two lake sediment core transects in the southwestern and southeastern embayment down to 23 m water depth (i.e. 28.6 m total sediment recovery) are studied.

The supra-littoral sequences revealed high-stand littoral sand and peat deposits on top of glaciolimnic, glaciofluvial sediments. They are overprinted by different palaeosoils representing modern and past terrestrial conditions. The high-stand deposits indicate to an up to 3 m higher than present lake level that was dated to the late Holocene (high Medieval time period) using standard AMS-^{14}C, palynostratigraphy and optically-stimulated luminescence (OSL) dating.

The lake sediment cores were stratigraphically described and analysed so far using µ-XRF scanning of the fine grained parts. Lake sediments are partly composed of sandy deposits intercalated with gyttja in the southeastern off-shore transect in 10 to 15.4 m water depth down to at least 4.4 m sediment depth. Sediments in larger water depths and the shallow cores in the southwestern transect are composed only of organic- and carbonate-rich gyttja with high, but very variable Ca-content. Preliminary correlations of Ca with other elements show either correlations with detrital components (K, Ti, Si), in places with Cl or point to an authigenic carbonate source.

Further statistical evaluations of the XRF-data integrating the future analyses of organic matter (TOC), grain size distributions, thin sections and dating of the off-shore sequences will allow a correlation with and an extension of the discontinuous on-shore pedosedimentary sequences to reveal the whole amplitude of lake level changes and sedimentary processes. These may be then linked to climatic and/or anthropogenic drivers of regional environmental changes.

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Sedimentation pattern in a shallow, strong through-flow dam reservoir (Włocławek Reservoir case study)

Gierszewski; Piotr[1,*] & Szmańda, Jacek[2]

[1] Polish Academy of Sciences, Institute of Geography and Spatial Organization, Toruń, Poland
[2] Jan Kochanowski University, Institute of Geography, Kielce, Poland
[*] Corresponding author: piotrg@geopan.torun.pl

The Włocławek Reservoir is situated in the lower Vistula river course. It is a classic example of a lowland reservoir of a valley type with a high water exchange (HRT of 5 days). The one consequence of the river damming is intensive sedimentation of clastic and biological material transported by the river. Besides diversified sedimentological environment changing with the growing depth and distance from the lakeshores, characteristic of lakes, the reservoirs also show diversity of sedimentological environments along the long profile. It is the function of the changing depth and flow velocity towards the dam. As a result of these changing depositional conditions three characteristic sedimentation environments develop: the sandy topset beds, sandy-silty foreset beds and bottomset beds which consist of fine sediments. The above pattern accurately reflects the conditions of sedimentation in deep reservoirs with low water exchange. In case of shallow reservoirs with fast water exchange the diversity of the sedimentation conditions is larger, which is connected with the high re-suspension and re-deposition activity.

Apart from characteristics of the deposits properties and the conditions in which they were deposited in the Włocławek reservoir, the aim of the study was also to recognise the depositional environments and the factors influencing the distribution of deposits types in the reservoir. Sedimentological analysis contains over 400 samples of bottom sediments from their upper 5-cm layer. The grain size analysis generally revealed the dominance of the silt deposits (72%). The second group is sands (24%) and the share of clay is only 4%.

The analyses of hydrodynamic conditions of sedimentation, based on the C/M diagram, proved that the accumulation comes mainly from the uniform suspension. However, traction and saltation are dominant depositional processes in the upper section of the reservoir and in the littoral zone of the lake part of the reservoir. Cumulative curves of grain size distribution show that, independent of the particle size, saltation is the dominant type of transportation. Silty suspension accumulating in the reservoir depends on the short-term re-suspension and re-deposition due to a great instability of the hydrodynamic conditions. This fact explains, among other things, the low level of sorting of the silt fraction. The results of the modelling indicate that in stormy conditions wind waves induce resuspension of the deposits down to the depth of even 8 m. This means that the redeposition takes place over approximately 40% of the bottom surface area of the lake section of the reservoir. Erosive conditions, limited to the scour parts of the deposited sediments, are present in the littoral and river zones as well as locally in shallower profundal parts. Accumulation conditions are limited to the deepest, isolated profundal parts and depend on the topography of the reservoir bottom.

Late Quaternary soil genesis and geomorphodynamics in Northern Poland

Hirsch, Florian[1,*]; Nicolay, Alexander[1]; Schneider, Anna[1]; Błaszkiewicz, Mirosław[2]; Kordowski, Jarosław[2]; Noryskiewicz, Agnieszka[2]; Tyszkowski, Sebastian[2]; Raab, Alexandra[3] & Raab, Thomas[1]

[1] Brandenburg University of Technology, Chair of Geopedology and Landscape Development, Cottbus, Germany
[2] Polish Academy of Sciences, Institute of Geography and Spatial Organization, Toruń, Poland
[3] Brandenburg University of Technology, Research Centre Landscape Development and Mining Landscapes (FZLB), Cottbus, Germany
[*] Corresponding author: hirschf@tu-cottbus.de

Within the scope of ICLEA, the working groups *lake sediments (WP4)* and *soil and geomorphology (WP5)* collaborate on the study site Wygonin in Northern Poland to characterize the landscape development after the Last Glacial Maximum (LGM). We use a combined pedological-sedimentological approach focusing on soil pits along catenas. The two soil toposequences studied in detail cross landforms where late Quaternary deposits of different age and facies are found. Findings from six soil pits and drillings along the toposequences were extrapolated by ground penetrating radar (GPR) lines. Preliminary results indicate a distinct reshaping of the post-LGM landscape that has resulted in fossilized soils on the toeslopes and comparably weak soil development on the backslopes. Soil stratigraphy, sediment properties and landform characteristics suggest that the main geomorphodynamic processes during the Holocene were gully erosion and subsequent colluvial fan sedimentation. Brunification and podzolization are the prevailing pedogenic processes in the recent and fossilized post-LGM sediments. ^{14}C datings of charcoal particles collected from soil profiles and pollen analysis of a peat section hint on several phases of landscape change since the Allerød. Our study therefore coincide with findings from the Northeast German Lowland which report distinct anthropogenic impact on landscape development at least in the Late Holocene with colluvial deposits as the correlate sediments of soil erosion.

Detection and attribution of lake-level dynamics in the Mecklenburg Lake District (northeast Germany) during the last decades

Kaiser, Knut[1,*]; Koch, Paul[1]; Mauersberger, Rüdiger[2]; Stüve, Peter[1]; Dreibrodt, Janek[3] & Bens, Oliver[1]

[1] Helmholtz-Centre Potsdam – GFZ German Research Centre for Geosciences, Scientific Executive Board, Potsdam, Germany
[2] Förderverein Feldberg-Uckermärkische Seenlandschaft e.V. Templin
[3] Helmholtz-Centre Potsdam – GFZ German Research Centre for Geosciences, Section 5.4 Hydrology, Potsdam, Germany
[*] corresponding author: kaiserk@gfz-potsdam.de

The lake-rich glacial landscapes of northeast central Europe play an important role for preserving and using of water resources, including protection of peatlands and biodiversity, mitigation of greenhouse gas emission, and promotion of tourism. In terms of both the last approx. 20 years and the future a regional 'syndrome of water shortage' has been frequently addressed, impairing particularly peatlands, flowing waters and lakes. The overall question to be addressed by this study is: What can regional gauging records tell us about decadal hydrological changes of lakes and their catchments? Accordant knowledge is of interest both for actual hydrology and for historical hydrology/palaeohydrology, supporting among other things the interpretation of long-term lake- and groundwater-level records. The investigation presented here belongs to a series of partly already published original and review studies (e.g. Kaiser et al. 2012a, 2012b), focusing on regional lake-level dynamics on various temporal (decadal to millennial) and spatial (from an individual lake to whole northeast Germany) scales. Generally, in the Mecklenburg Lake District most gauging records in lakes start not earlier than the late 1990s. Forty-five lake-level records from three large protected areas (one National Park, two Nature Parks) were analysed by hierarchical agglomerative clustering, looking for the trend in the period 1998-2008. The analyses show that lake levels had a different dynamics (reflected by trend groups), namely a negative (group 1), no clear (group 2) or even a positive trend (group 3). The proportion between this three groups is 23 (51 %) to 15 (34 %) to 7 lakes (15 %), respectively. In group 1 (mostly groundwater-fed lakes) lake-level changes depend on groundwater-level changes. These in turn are widely controlled by decreasing groundwater recharge in the catchments caused by specific (warm-dry) weather conditions in the observation period and the impact of the dominating highly water-consuming pine forests. In group 2 (mostly stream lakes), direct human impact drives the local lake level by management of weirs and ground sills. All lakes in group 3 (river, stream and spring lakes) were subject to impoundment measures initiated by nature restoration projects. Beyond the 10 year-time window analysed further regional data provide hints on the multi-decadal to secular dynamics of groundwater-fed lakes. As the few longer lake-level time series available since the 1950s at the earliest suggest, periodic lake-level fluctuations with amplitudes of approx. 1-2(-3) m are characteristic for regional groundwater-fed lakes.

This ICLEA study is co-financed by the Helmholtz Association climate initiative REKLIM topic 4 "The land surface in the climate system".

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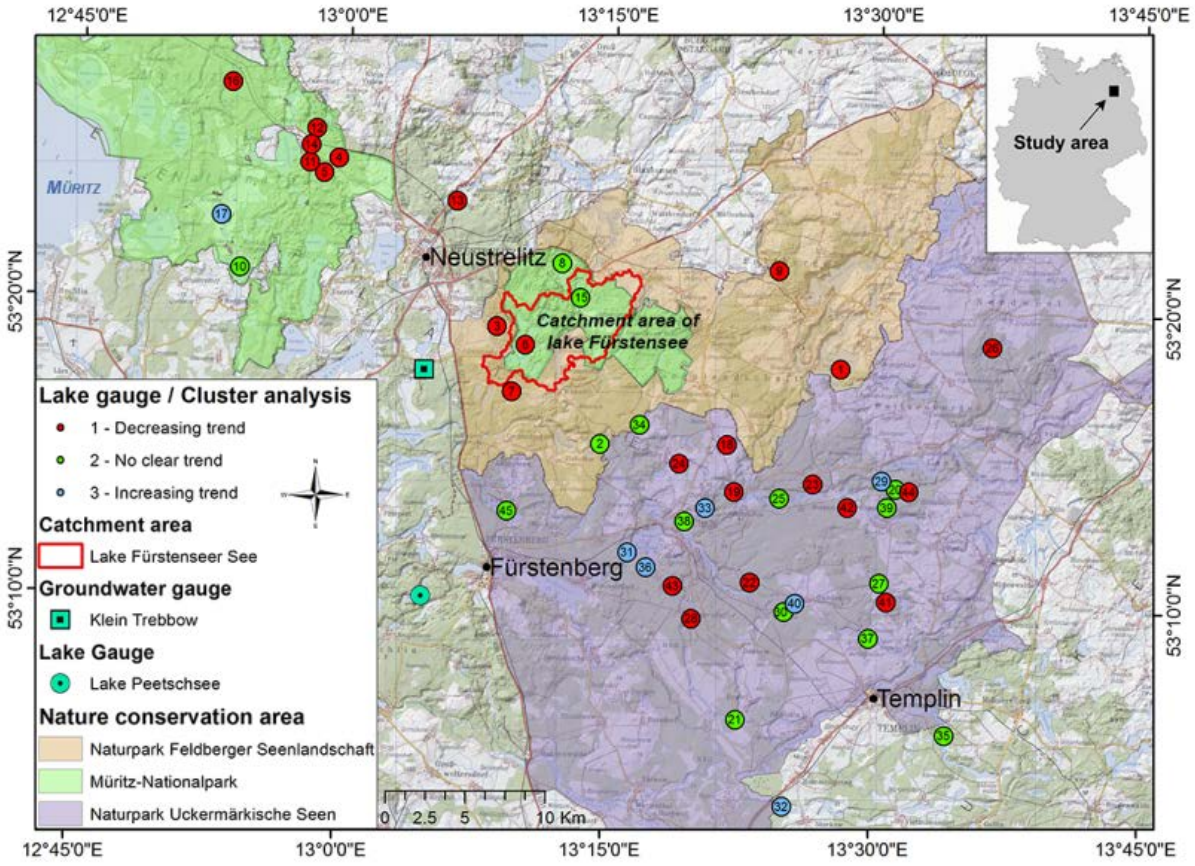

Figure: Map of the study area in the Mecklenburg Lake District showing the distribution of the lakes analysed (lake-level trend in the period 1998-2008), located in large protected areas ("Großschutzgebiete" in German), and some further information. The numbers in the lake gauge symbols (red = decreasing trend, green = no clear trend, blue = increasing trend) refer to the lake identities.

Kettle-holes deposits in the light of geological and GPR study

Karasiewicz, Mirosław T.[1,*] & **Lamparski**, Piotr[2]

[1] Department of Geomorphology and Palaeogeography of the Quaternary, Faculty of Earth Sciences, Nicolaus Copernicus University, Lwowska 1, 87-100 Toruń, Poland
[2] Department of Environmental Resources and Geohazards, Institute of Geography and Spatial Organization, Polish Academy of Sciences, Kopernika 19, Toruń 87-100, Poland
[*] Corresponding author: M.T.Karasiewicz@umk.pl

Small ground depressions with no surface outflow are characteristic elements of young post-glacial landscapes. Their genesis is often associated with melting glacier or overflow (icing) ice (so-called kettle-holes). The main aim of our study was to determine the scale, dynamics, characteristics and time of the sedimentation of autochthonous and allochtonous material in the bottom of kettle-holes. This problem was considered within the context of natural and anthropogenic conditions in the period from Late Glacial and early Holocene to the present (Karasiewicz&Hulisz 2011). The study was carried out in minor kettle-holes with small internal catchments of up to 5 hectare. They were characterized by clearly defined slopes and bottoms, filled with postgenetic (lacustrine, organic and colluvial) sediments. The kettle-holes can be treated as “sediment traps”. They play an important role as archives of the environmental processes and phenomena which have occurred within their catchments. Each site represented a different morphogenetic type: site A (Popówka) - an outwash plain; site B (Zbójenko) – a drumlin field, and site C (Retno) - a kettle-hole located on the moraine plateau. These areas were still covered by the Vistulian Ice Sheet 18.8 thousand years ago.

Two antennae were applied for the ground penetrating radar tests - 400 MHz shallow-range, high-resolution and 35 MHz one, deep-range and low-resolution (Lamparski 2008). Both with the GSSI SIR SYSTEM-2000™ radar device. GPR cross-sections led to the separation of the organic deposits from the clastic ones in almost all the kettle-holes down to its bottom and gave the pattern of anomalies that reflect the internal structure of organic deposits (Fig. 1).

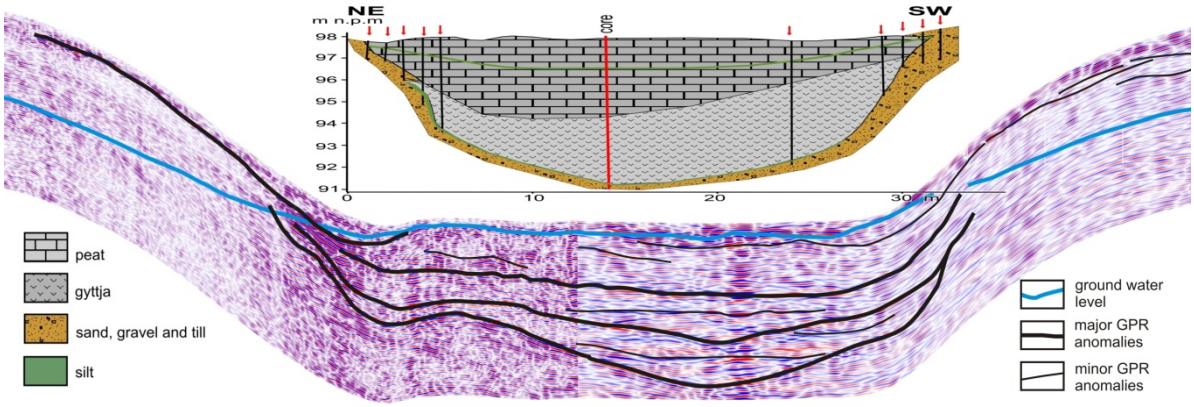

Fig.: Comparison of the geological cross-section with the GPR radargram at Retno kettle-hole.

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Old Vistula River Lake in the Light of Cartographic, Sedimentological, Hydrological and Hydrochemical Investigations (Grudziądz Basin, North Central Poland)

Kordowski, Jarosław[1,*]; Kubiak-Wójcicka, Katarzyna[2]; Solarczyk, Adam[2] & Tyszkowski, Sebastian[1]

[1] Polish Academy of Sciences, Department of Environmental resources and Geohazard, , Institute of Geography and Spatial Organization, Toruń, Poland
[2] Nicolaus Copernicus University, Institute of Geography, Department of Hydrology and Water Management, Toruń, Poland
* Corresponding author: jarek@geopan.torun.pl

Lower Vistula River valley is rich in many fluvial lakes some of which do exist for thousands of years in spite of flood sediments accumulation. As an attempt to solve the problem of persistence of such lakes there were undertaken investigations relying on old cartographic sources inventory, sedimentological, geomorphological, hydrological and hydrochemical observations within the fluvial lake in the vicinity of the Grudziądz town and for comparison in the main river channel. The results revealed strong relation between physical and chemical changes of water properties upon the rate of ground-water discharge and the local weather conditions (intensity of winds). This occurrence was intensified by low water levels in the channel, ones of the lowest in the 50 year time span of observations. The observed increase of suspended matter concentration was in most cases asynchronous with main channel which along with the continual outflow from ground-water supply indicates the possibility of sediment removal from fluvial lakes provided they are connected to the main channel even during low water levels.

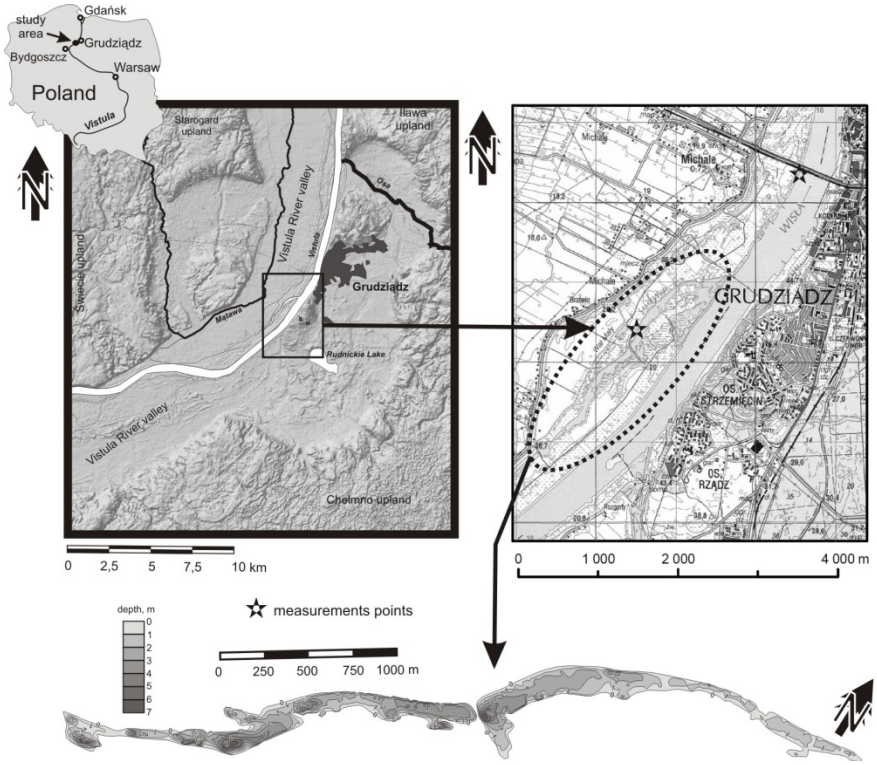

Figure: Location maps of the investigated fluvial lake in the lower Vistula valley.

Aeolian sands and buried soils in the Mecklenburg Lake District (Boek, NE Germany): Holocene land use history and pedo-geomorphic response

Küster, Mathias[1,*]; Fülling, Alexander[2]; Kaiser, Knut[3] & Ulrich, Jens[4]

[1] University of Greifswald, Institute of Geography and Geology, Greifswald, Germany
[2] Humboldt University of Berlin, Institute of Geography, Berlin, Germany
[3] Helmholtz-Centre Potsdam – GFZ German Research Centre for Geosciences, Scientific Executive Board, Potsdam, Germany
[4] State Archaeological Survey of Mecklenburg-Vorpommern, Schwerin, Germany
[*] Corresponding author: mathias.kuester@uni-greifswald.de

Dunes are formed under naturally (Late Glacial) or man-made (Holocene) open conditions. From the Mecklenburg Lake District, Holocene drift sands and dunes have been documented but not well dated so far (e.g. KAISER et al. 2002).

We here aim to study dune formation in a drift sand area on the shore of Lake Müritz. The study is based on a pedo-geomorphic approach, i.e. we explore the formation of dunes by studying the stratigraphy of the dune sediments, the soils and the shape and development of the dunes. The analysis is complemented by palynological records, archaeological data and regional history.

Triggered by intensified settlement and land use, aeolian activity accelerated during the 13th and in the 15th to 16th century AD. The population decline during the Thirty Years War started a period of stability that continued through the 18th century. A final period of high aeolian activity was triggered by the establishment of glassworks during 19th century AD.

We conclude that Holocene aeolian dynamics was directly linked to human activities. The investigated drift sand units are morphologically, stratigraphically and sedimentologically heterogeneous, reflecting the spatial and temporal variability of Holocene human impact.

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Mesolithic to Late Roman Iron Age / Migration Period landscape and soil development – results from archaeological and soil-geomorphological investigations nearby Jänschwalde, Lower Lusatia

Nicolay, Alexander[1, *]; **Schulz**, Deborah[2]; Raab, Thomas[1] & Raab, Alexandra[3]

[1] Brandenburg University of Technology, Chair of Geopedology and Landscape Development, Cottbus, Germany
[2] FU Berlin, Institute of Prehistoric Archaeology, Berlin, Germany
[3] Brandenburg University of Technology, Research Centre Landscape Development and Mining Landscapes (FZLB), Cottbus, Germany
[*] Corresponding author: alexander.nicolay@tu-cottbus.de

Within the apron of the opencast mine Jänschwalde (SE Brandenburg, Germany) archaeological excavations on a multiple populated small dune were complemented with soil-geomorphological investigations in the surroundings. Archaeological findings in the dune stratigraphy (especially cremation graves) are intercalated within aeolian sediments and/or buried soils and thus give a record of the Late Quaternary geomorphodynamic and soil development.

The archaeological results confirm the presence of Mesolithic and Neolithic populations at the study site. The Meso- to Neolithic factory sites are preferably located on slightly elevated places like the remnants of late glacial dunes. On these late glacial aeolian sediments subsequently a podzol formation took place, indicating stable environmental conditions. At the excavation site, this soil was buried by aeolian drift sands in which a cemetery was found. According to grave goods and grave type the excavated bi-ritual cemetery was created at the end of the 3rd and used until the early 5th century AD (Late Roman Iron Age to Migration Period). Within this period the aeolian activity, proven by about 1 m deep drift sands, increased and a small dune was formed wherein 4 inhumation and approx. 26 cremation graves (*Schichtgräberfeld*) were documented. The cremation graves were mainly recorded as small reddish/gray 5-20 cm thick sandy layers which were separated by the drift sand layers.

Soil-geomorphological investigations, two kilometers north of the excavated cremation and settlement site corroborate the detected phases of morphological stability and aeolian activity in this time period. Our complementing investigations indicate that the Late Roman Iron Age to Migration Period population had affected the landscape due to deforestation and agricultural land use.

An early industrial charcoal production area in Lower Lusatia (Germany) - a GIS based reconstruction of past landscapes with historical maps from the 18th and the 19th century

Takla, Melanie[1]; Raab, Thomas[1] & Raab, Alexandra[2]

[1] Brandenburg University of Technology, Chair of Geopedology and Landscape Development, Cottbus, Germany

[3] Brandenburg University of Technology, Research Centre Landscape Development and Mining Landscapes (FZLB), Cottbus, Germany

[*] Corresponding author: melanie.takla@tu-cottbus.de

In the apron of the open-cast mine Jänschwalde (Lower Lusatia, Germany) scientists of the BTU Cottbus and archaeologists of the BLDAM jointly investigate the human-landscape interrelationship. In the scope of the project is the charcoal burning which was presumably carried out from about the 16th to the 19th century. So far c. 900 ground plans of circular upright kilns have been documented by the BLDAM. The kilns are dated to the 18th and 19th century due to first results of dendrochronological age determination (K.-U. Heußner, DAI Berlin). Written records proof that the main part of the charcoal has been produced for the smelter at Peitz nearby. This study aims to reconstruct the spatial dimension of the charcoal burning and the consequences for the woodland and the environment by means of GIS and historical maps of the 18th and the 19th century. Digital landscape data, archaeological data and historical maps and information from archives and literature are combined and evaluated ad hoc.

Starting point for the reconstruction are recent landscape data which are well reflecting the natural and cultural situation of the landscape (e.g. land use data, digital elevation model). The work is accomplished by digitizing back stepwise selected landscape elements like forest boundaries, forest structures and transportation network from present time to the 18th century on the basis of georectified historical maps. According to the availability of those maps two time periods have been selected: the second half of the 18th century (*Schmettausche Karte)* and the 19th mid-century (*Urmeßtischblatt).* Archaeological data, historical forest maps and information from archives are used for validation and completion. The data situation of the charcoal kilns could be enlarged by over 5000 additional kilns which have been identified and digitized from Shaded Relief Maps based on high resolution LIDAR data. All kilns are stored together with other relevant information like size, age, etc. in a database. The spatial kiln distribution and relation to physical and socio-economic parameters will be evaluated statistically. Calculations of wood consumption based on the diameters of the kilns will be set into relation with the size and the structure of the wood in the mentioned time periods.

The role of landslides in current process of shaping the escarpment zone of river valleys (example of Lower Vistula Valley)

Tyszkowski, Sebastian[1,*]

[1] Polish Academy of Sciences, Department of Environmental resources and Geohazard, Institute of Geography and Spatial Organization, Toruń, Poland

[*] Corresponding author: sebtys@wp.pl

Landslides in Poland are mainly located in the flysch Carpathian Mountains, but they also can be found in deep river valleys on lowlands. In this geomorphology position in the middle of Lower Vistula Valley between Bydogszcz and Świecie (53°12'N 18°11E, 53°25'N 18°30'E) the study areas of analyzed landslides` activity were located. Landslides in river valley usually develop in quaternary tills, sands and clay. Particularly important is the 6 meter thick, pliocen clay layer, with glacitectonics deformation, in the lower part of slopes near Bydgoszcz.

Determination of contemporary activity of landslides in escarpment zone bases on of field work, such as detailed inventory and documentation of the landslide forms, geotechnical and geological drillings, geodesic measurements, and analysis of aerial photography.

The research revealed a significant role of landslides in old and contemporary shaping the relief of the escarpment zone in the Lower Vistula Valley. Detailed inventory and documentation of landslides on test areas indicated the existence of nearly 200 landslides ranging in size from 100 to more than 70,000 m^2. Most common type of landslide are shearing slides, often in the multiple rotational form. Mostly the landslides width does not exceed 100m and length remains below 200m while their height can reach 20m.

The role of landslide movements and their intensity as a process of shaping the relief has evolved over the time, since the beginning of the formation of the escarpment zone of the Lower Vistula. Contemporary active forms make 30%, regularly active 38% and inactive 32% of the identified landslides. These elements determine the characteristics and the extent of the local landslides. Depending on the geomorphological zones, landslide cover 6-30% of the area of the slopes. An estimation indicates that there occur approximately 3-20 landslides on 1 km of escarpment zone in the slope area.

Currently, on the study area the most important factor of landslides activation is precipitation. In cases of extreme rainfall events, such as during the summer of 1980, a widespread activation of mass movements may appear.

This study was partly supported by the Ministry of Science and Higher Education (grant N N306 086037 in 2009-2012) and the Virtual Institute of Integrated Climate and Landscape Evolution (ICLEA) of the Helmholtz Association.

Preliminary analysis of land use changes over the last 200 years in the catchment of Lake Czechowskie

Tyszkowski, Sebastian[1,*] & Kaczmarek, Halina[1]

[1] Polish Academy of Sciences, Department of Environmental resources and Geohazard, Institute of Geography and Spatial Organization, Toruń, Poland
[*] Corresponding author: sebtys@wp.pl

Land cover of the lake catchment, understood as land use, is one of the most important factors influencing the processes occurring within the water body. In the case of the catchment of Lake Czechowskie the particularly important land cover elements are forest communities in the area and the changes associated with them, mainly deforestation or afforestation.

At the preliminary stage of the land cover analysis it was decided to consider historical changes in the lake's surface catchment, which covers an area of nearly 20 km^2. The analysis of changes in the forest cover was based on archival and contemporary cartographic and photogrammetric materials rectified in the GIS software. The following materials were used: Karte von Ost-Preussen nebst Preussisch Litthauen und West-Preussen nebst dem Netzdistrict, 1:50 000, section 92, 93, 1802-1806; Map Messtishchblatt, 1:25000, sheet Czarnen, (mapping conducted in 1874), 1932; Map WIG (Military Geographical Institute - *Wojskowy Instytut Geograficzny*), 1:25000, sheet Osowo, (mapping conducted in 1929-31), 1933; aerial ortophotomap, 1:5000, 2006.

Today, over 60% of the catchment of Lake Czechowskie is covered with forests, which take the surface area of 12 km^2. It is primarily a pine monoculture. The largest complexes of dense forest are located in the western and southern part of the catchment, while the northern part is either used for agricultural purposes or is built up. The first cartographic materials indicate that in the late 18th c. the forest coverage was largely similar to that of today. The then area occupied by forests amounted to almost 50% of the catchment surface. Differences in forest cover are observed to the south and southeast of Lake Czechowskie as these areas did not use to be covered with forest. Over the next 50 years there was a significant reduction in the forested area. It fell by over 30% to about 8 km^2. Deforestation mainly referred to the southern part of the catchment near Lake Czechowskie and the area between the villages Piece and Kaliska. The following years brought a gradual increase in forest cover. In the 1920s the forest cover increased to 8.8 km^2. The forested section primarily included the northern part of the catchment while the fragmented forested areas to the southeast of Lake Czechowskie were linked together. Today, almost the entire lake is surrounded by a forest and wetland belt at least 0.5 km wide.

Changes which took place in the catchment should not be equated solely with the logging because the area of the Tuchola Forests was repeatedly affected by natural disasters. In the 19th c. these predominantly included fires, while in the 20th c. - the activity of pests.

Human activity in the catchment of Lake Czechowskie, shown on the cartographic materials from the turn of the 18th and 19th c., is also manifested by the creation of dams. Such an object is a water mill located at the outlet from the lake in the village of Młyńsk, whose presence might have affect the increase in the water level in the lake.

The 20th c., imaged on the WIG maps, was a period of intense change leading to agricultural use of wetlands. The drainage works were carried out in the form of construction of canals, and included the Trzechowskie peatland as well as wetlands north of Lake Czechowskie.

This study is a contribution to the Virtual Institute of Integrated Climate and Landscape Evolution (ICLEA) of the Helmholtz Association.

Introduction to ICLEA fieldtrips – Stara Kiszewa 2013

Mirosław Błaszkiewicz[1], Brian Brademann[2], Achim Brauer[2], Dariusz Brykała[1], Marek Degórski[1], Wojciech Froehlich[1], Piotr Gierszewski[1], Florian Hirsch[3], Halina Kaczmarek[1], Jarosław Kordowski[1], Mateusz Kramkowski[4], Jarmila Krzymińska[5], Piotr Lamparski[1], Monika Lutyńska[6], Joanna Mirosław-Grabowska[7], Alexander Nicolay[3], Agnieszka Noryśkiewicz[8], Bożena Noryśkiewicz[8], Milena Obremska[7], Florian Ott[2], Alexandra Raab[3], Thomas Raab[3], Anna Schneider[3], Markus Schwab[2], Michał Słowiński[1,2], Sebastian Tyszkowski[1], Sabine Wulf[2], Izabela Zawiska[1]

1 – Institute of Geography, Polish Academy of Sciences
2 – GeoForschungsZentrum, Potsdam, Germany
3 – Brandenburg University of Technology, Cottbus, Germany
4 – Kazimierz Wielki University, Bydgoszcz, Poland
5 – Polish Geological Institute – National Research Institute
6 – Adam Mickiewicz University, Poznań, Poland
7 – Institute of Geological Sciences, Polish Academy of Sciences
8 – Nicolaus Copernicus University, Toruń, Poland

The ICLEA fieldtrip area is located in northern Poland and includes the northern part of the Tuchola Forest and the Starogard Lake District (Kociewie Region). This area was entirely covered by the last Weichselian ice sheet (Fig. 1). During its retreat, a distinct marginal zone associated with the Pomeranian Phase developed here. It is characterised by the proximal zones of outwash plains as well as the sedimentary contact between the ice and the upper, proximal level of the outwash plain in the vicinity of Stara Kiszewa (Błaszkiewicz 2005a, b), (Fig. 2). The current state of knowledge regarding the character of the Pomeranian Phase in the study area does not allow a precise reconstruction, but the absence of both marginal forms with glacitectonic structures and individual till layers suggest that it represents only the stagnation phase in the hinterland during the overall ice sheet retreat.

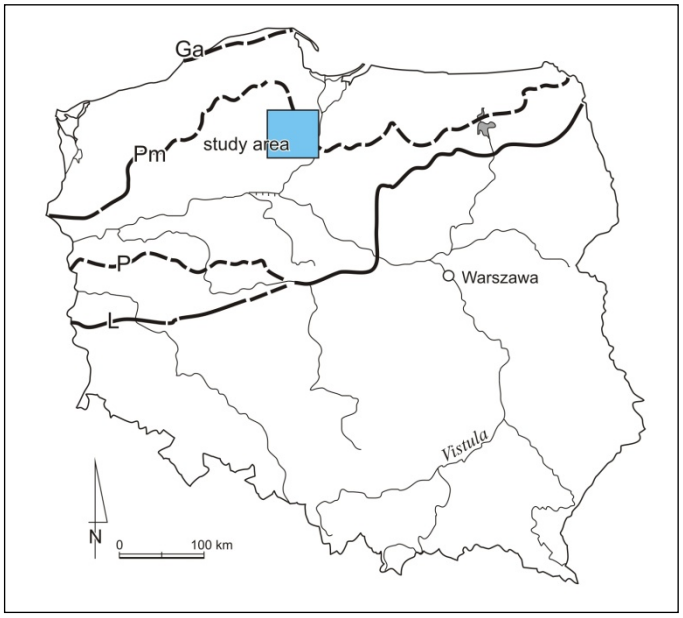

Fig. 1. Map of Poland with the location of the ICLEA trips area and maximum extent of the Late Vistulian ice sheet (after Kozarski, 1975). L = Leszno phase (Brandenburgische Stadium); P = Poznań phase (Frankfurter Eisrandlage); Pm = Pomeranian phase; Ga = Gardno phase.

The lack of interstadial organic deposits dating from before the Pomeranian Phase implies that the Pomeranian Phase can be dated only indirectly. Based mainly on datings of the later Gardno Phase (14.5-14.3 ^{14}C kyrs BP following Rotnicki and Borówka 1994, 1995; Rotnicki, 2001), it is deduced to have ranged from 16.2 ^{14}C kyrs BP (Kozarski, 1995) to 15.2 ^{14}C kyrs BP (Marks, 2002). This age range may also apply to the formation of the depressions which would become lake basins during the Late Glacial and Early Holocene.

The relief of the fieldtrip area is developed in the forefield of the Pomeranian Phase and is dominated by extensive outwash plains built of sand/gravel deposits of up to 30 m in thickness. The most important surface features are numerous subglacial channels associated with the glaciation and dune fields formed during the main dune-forming phase in the Younger Dryas (Błaszkiewicz et al., 2006, Kaiser et al., 2010). The hinterland of the Pomeranian Phase is dominated by an undulating moraine plateau with numerous subglacial channels which are often incorporated in river-valley systems. The plateau areas commonly show a characteristic kame and kettle holes relief, which indicates a mixed areal nature of the ice sheet disappearance during the retreat following the maximum extent of the Pomeranian Phase.

Permafrost remained present in the study area when the ice sheet retreated. This is evident from, among other features, thermal contraction cracks, oriented kettle holes on the outwash plains, and the frost-related transformation of soils (Van Loon et al., 2012). It has been found on the basis of the lowermost lacustrine sediments that the start of lacustrine sedimentation was asynchronous in the Starogard Lakeland, which had been covered by an ice sheet during the last glaciation. Most lakes appeared in the Bølling-Allerød complex, but older lakes had already formed before the Allerød, whereas other lakes came into being only at the end of the Preboreal (Błaszkiewicz, 2005a).

The main reason for the difference in the formation of the lakes was due to the diversity of melt-out processes of the buried dead-ice blocks. The melting intensity differed after the moment of ice-sheet retreat and lasted in some depressions until the end of the Preboreal. Particularly important for the preservation of blocks of dead-ice was the constant or interrupted character of the drainage of the depressions, especially for the depressions in the vicinity of a water course that was subject to downward erosion during the Late Glacial.

On the other hand, local morphological conditions favored longer preservation of stagnant water, and the thermal effect of water above the dead-ice led to rapid melting and to the establishing of a lake basin at the beginning of the Late Glacial. The melt-out of buried dead-ice blocks, under thermokarst conditions, was very fast regardless of how long that dead-ice had survived. The long-term preservation of the lake basins as a consequence of the presence of buried dead-ice blocks not only indicates the presence of Late Glacial permafrost in the areas covered by the last ice sheet, but also provides evidence for the timing of its ultimate disappearance. The probable age of the final degradation of permafrost in this area is the end of the Preboreal (Błaszkiewicz, 2011).

Stop 1 - Boże Pole Szlacheckie – sedimentological record of the beginning of the lake development in the context of buried ice melting

The presented site is located within a large, basin-like depression, included by the Wierzyca in its valley course (Fig. 2). It is over 4 km long and nearly 3 km wide. The axis of the depression takes the shape of an arc open to the north. The elevation difference between the mineral bed of the depression, taking into

account the thickness of the organic filling, and the upper edge of the high outwash plain level is over 55 m. The morphology of the depression, in conjunction with the fact that it is located at the hinterland of the sedimentation edge of the high outwash level, suggests this form is a terminal depression.

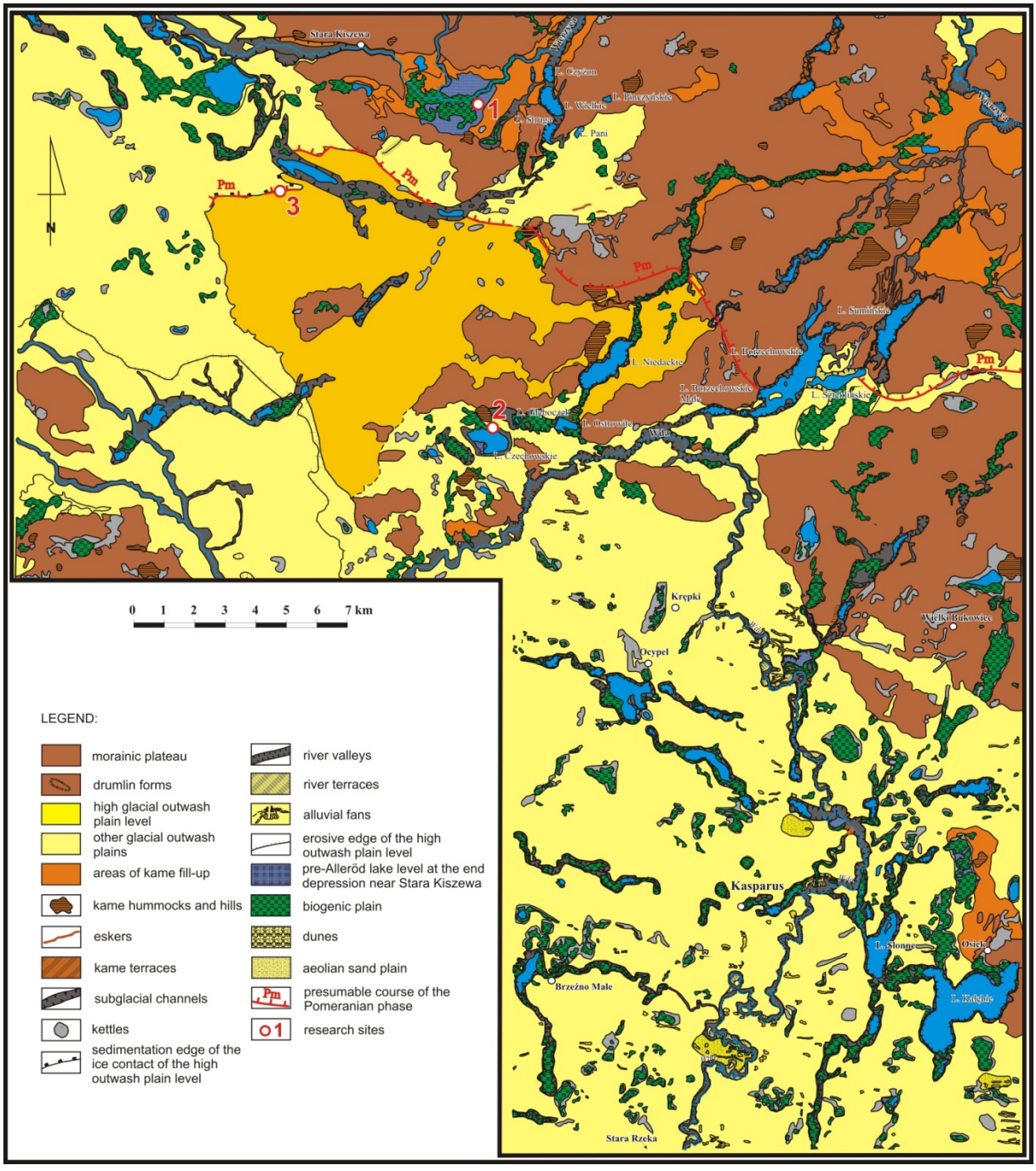

Fig. 2. Geomorphological sketch of the western and central part of the Starogardzkie Lakeland (map sheets of Stara Kiszewa, Zblewo and Osiek SzMGP 1: 50 000 – Błaszkiewicz 2005 b,c; 2006)

The terminal depression contains a whole range of forms the genesis of which is linked to the phase of the final deglaciation of the analysed area. In addition to the plain of organic deposits (112-113 m) which fill up the mineral floor, there are two very distinctly defined levels of 126-129 m and 115-123 m, respectively, separated from each other with edges.

The higher of them (126-129 m) is defined as a kame terrace, accumulated in the slope zone of the depression in the first phase of the deglaciation of the area. The other, lower level (115-123 m) is the most characteristic morphological feature of the terminal depression. It is found in several large fragments surrounding almost the entire floor of the depression. This level is separated from both the moraine plateau and the previously described kame level (126-129 m) with distinct edges sometimes exceeding 10 m. A characteristic feature in the morphology of the surface level is the existence of numerous melt-out kettle depressions. The diameter of some of them is up to 200 m. A particular concentration of kettle holes is observed in the inner part of the level, at the contact with the morainic plateau. The level in the northern part is erosively cut by the Wierzyca's tributary Mała Wierzyca, and in the eastern part – by the Wierzyca itself. The exposure presented to the participants of the second ICLEA workshop is located in such a cut.

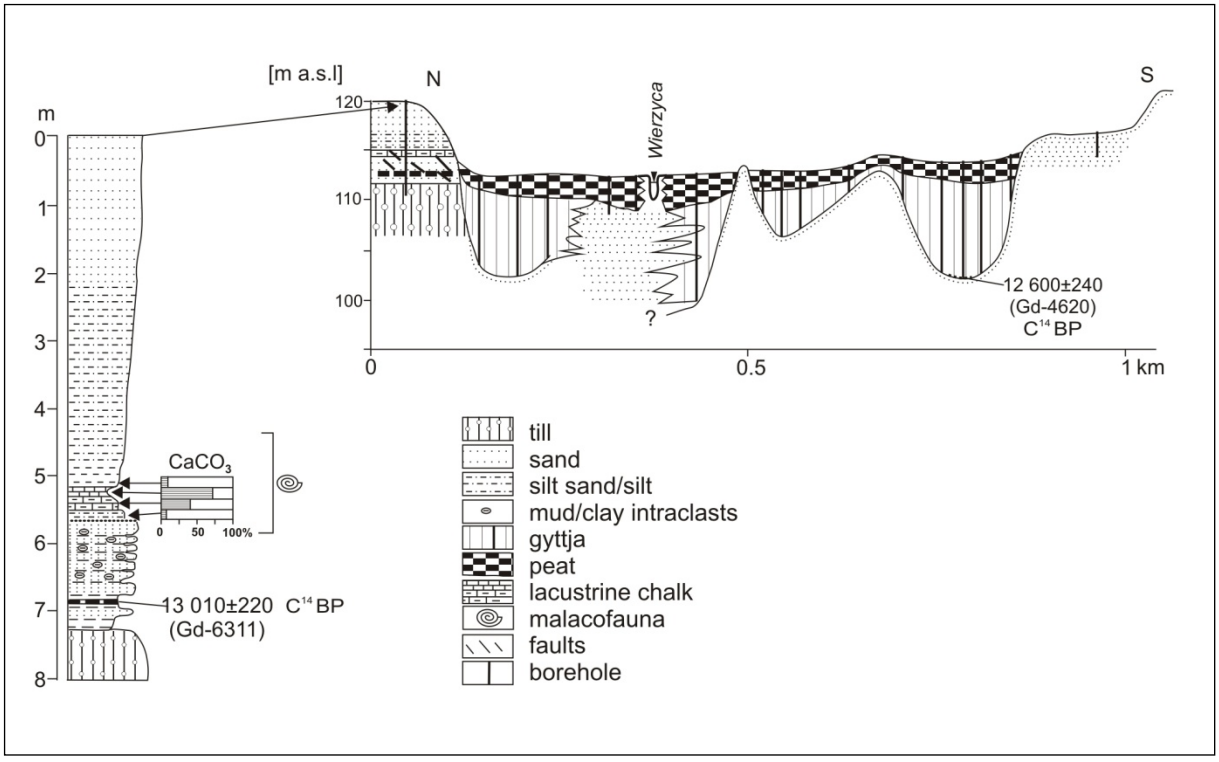

Fig. 3. Cross -section trough the bottom of a depression near Stara Kiszewa.

The level includes a 7-m sand/mud/carbonate lacustrine succession on top of a sandy ablation till (Fig. 3). The lowermost unit of this succession consists of alternating massive muds and massive sands with a large amount of mud/clay intraclasts. At a depth of 6.6 m, between layers of clayey mud, a discontinuous peat layer is present. It has been dated at 13,010±220 ^{14}C yrs BP (Gd-6311) and contains a Dryas flora (with, among other taxa, *Salix, Betula nana, Dryas octopetala, Selaginella selaginoides*). Directly above these deposits a 0.5-m thick carbonate layer occurs, containing malacofauna with cold-loving species of the Holarctic range (Błaszkiewicz and Krzymińska, 1992); it is covered by clayey/muddy/sandy deposits that form a succession of 5 m in thickness.

All deposits in the bottom part of the exposure, down to the carbonate layer, are cut by a network of normal faults with vertical displacements up to 20 cm (Fig. 3). Along the fault lines, continuous deformations appear at the bottom of the carbonate layer in the form of small bends, while the overlying layer is not disturbed. The geological structure of the level records the full life cycle of a pre-Allerød lake, from the shallow backwaters of a wetland character, through a gradual deepening of the lake basin as a result of melting of the ice in the substratum, to the shallowing of the lake as a result of intensive supply of clastic material.

The above pre-Allerød lake was drained in the middle Bølling towards a nearby channel. This is indicated by radiocarbon (12,600±240 ^{14}C yrs BP – Gd-4620) and palynological datings of the peaty mud located at the base of the lacustrine sediments in the centre of the marginal depression (biogenic-alluvial floodplain) that already had formed in the younger-generation lake. Lack of pre-Allerød sediments suggests that the functioning of these oldest lakes was limited to small spaces between the slopes of the depressions, and the blocks of dead ice filling most of the depressions.

The analogy with the oldest generation of the lakes in the Biesenthal Basin near Berlin (Nitz et al., 1995) is obvious. Moreover, such a situation indicates a time gap in lacustrine sedimentation between the accumulation in pre-Allerød lakes and the successive younger generation of lakes which developed at the lower morphological levels of the depressions. In the case of the marginal depression near Stara Kiszewa, it lasted only until the middle Bølling.

Stop 2 Lake Czechowskie – environmental conditions of the sedimentation course Geomorphological and sedimentological research

The basin of Lake Czechowskie occupies a deep depression located in the immediate hinterland of the maximum range of the Pomeranian Phase ice sheet (Fig. 2). In the surroundings of the depression there are morphologically diverse outwash areas (Fig. 4). Only in the north there is a kame hill nearby the edge, while in the east the edge of the depression is adjacent to the morainic plateau. The depression has generally a rounded shape. Only its north-western part has a form of a channel branch. The edges of the form are very distinct, of a height of up to 30 m. The maximum depth of the depression, when taking into account the depth of the lake and the thickness of the lake sediments, exceeds 70 m! Such morphology suggests the depression is a deep subglacial channel developed by the erosion of subglacial waters. Subglacial water did not only cut the glacial deposits of the Weichselian Glaciation, but also of the Oder Glaciations (Błaszkiewicz, 2005 a).

The central part of the subglacial channel is occupied by Lake Czechowskie and the biogenic plain to the north-east of the lake (Fig. 4). The lakeshore of Lake Czechowskie contains traces of a higher by about 2.0 m lake water level if compared to the current situation. These are more or less explicit lakeside terraces built of gyttja, silts and lake sands. One of the morphologically better developed lake terraces is located in the southern part of the lake basin. In its structure, in the surface there is about 15 cm of lacustrine chalk overlying a glacilimnic complex of silty-fine-sand rythmites. The first palynological analyses of the lake sediments building a small lake terrace in the south-western part of the lake basin indicate that the largest extent of Lake Czechowskie took place in Allerød.

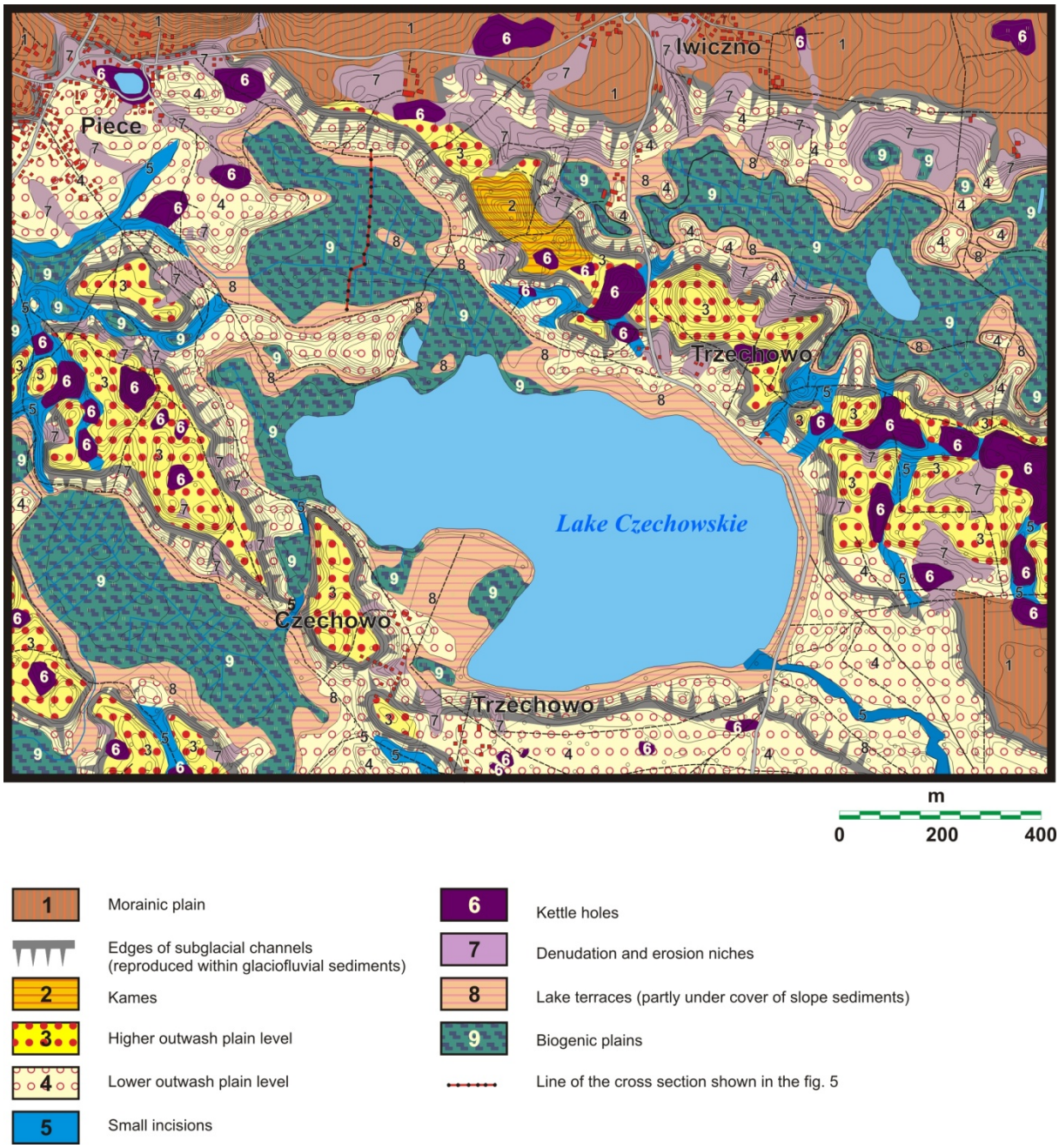

Fig. 4. Morphological sketch of the Czechowskie Lake vicinity.

Drilling carried out within the vast peat plain in the western part of the lake basin indicate that there are very diversified lake sediments of up to 12 m in thickness (Fig. 5). At the same time, one can point to a varied morphology of the original lake basin. The lithological development of deposits in this part of the lake basin was decisively influenced by the morphology of the water floor and the water depth. Sediments within small local deeps show a more detritous character than the deposits located closer to the present-day lake. Virtually all profiles at the base of lacustrine sediments contain a layer of carbonate gyttja, which then transform into more organic gyttja and in the ceiling change into carbonate gyttja again. Gyttja in the floor sections often shows lamination. The profiles record numerous episodes of underwater landslides and reduced water levels shown in the form of unsorted sandy material within the gyttja. Most frequently such

situations were documented in the littoral zone. Currently, geochemical analyses of the deposits as well as their dating are underway in order to determine water level fluctuations.

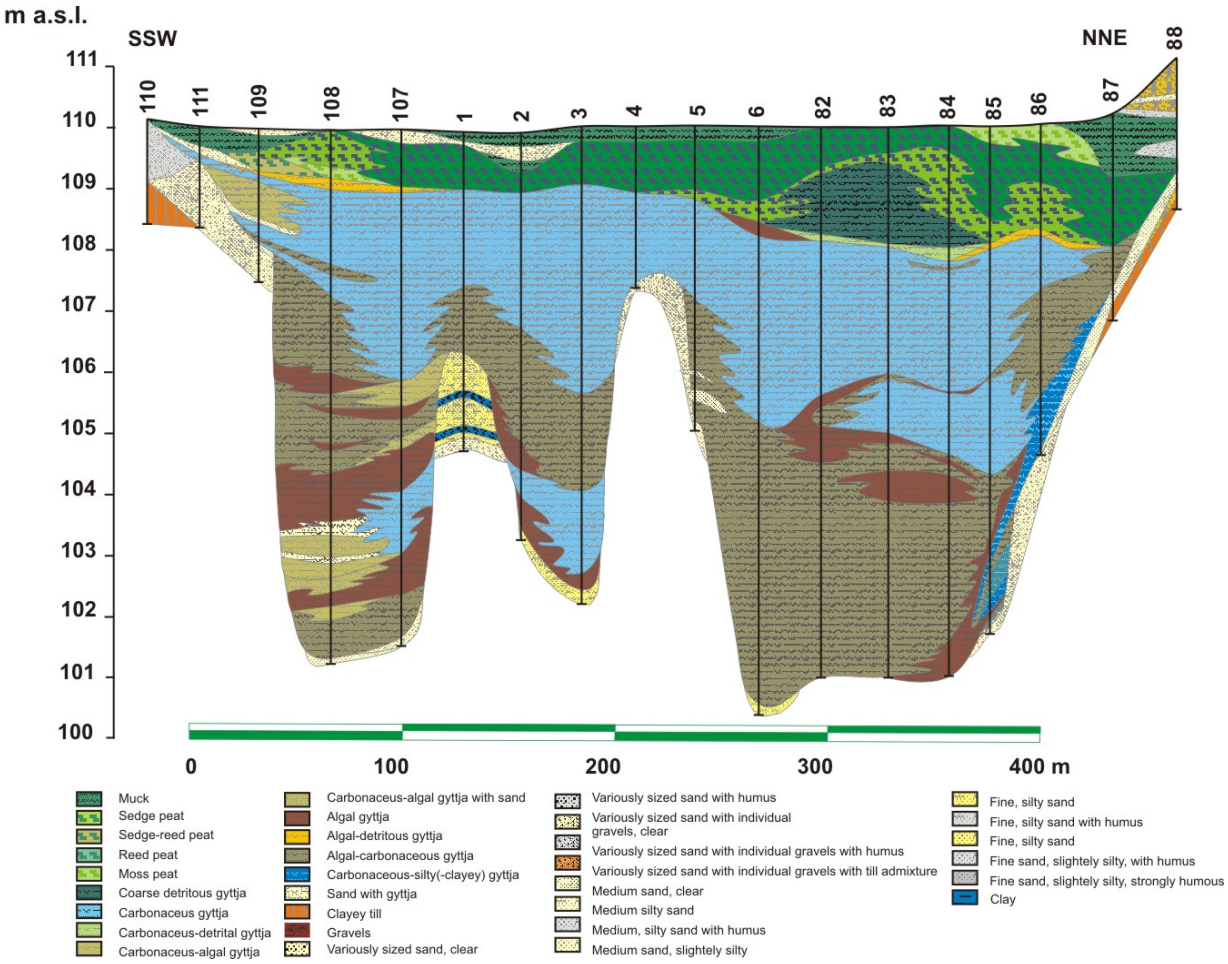

Fig. 5. Exemplary cross section through limnic and telmatic sediments of the Czechowskie Lake biogenic plain developed in the west side of the recent waterbody.

Deposits in the recent lake basin

As a former subglacial channel the lake is divided into two parts. The deeper eastern basin (maximum water depth of 32 m) is separated from the shallower western part (12 m water depth). A relatively flat threshold between the deeps is at the depth of about 9.5 m.

The carried out drillings revealed a very high variability of the thickness of the Lake Czechowskie's sediments. In the drilling in the threshold, on the sandy-gravel mineral substrate is a meter of carbonate gyttja, dark and grey-cream at the bottom and light-cream at the top. In the deep whose actual depth is only 3 m greater than the depth of the threshold, the maximum thickness of the lake deposits is 10.7 m. In a relatively small space it is very well visible that the thickness of the bottom sediments depends on the topography of the mineral surface which was the primary floor of the lake basins.

The profile of the lacustrine sediments in the shallower deep (13 m) starts with a series of Late Glacial mineral-carbonate gyttja of over 1 m in thickness. In its bottom part, directly on the sandy-gravel mineral

substrate is a few-cm layer of clayey silt, covered with the Allerød mineral-carbonate gyttja, which contains 20-41% of carbonates, 5-19% of organic matter and 39-76% of mineral parts. This gyttja is characterised by not very distinct microlamination. Late Glacial sediments end with an about 20-cm layer of organic clayey silt of the Younger Dryas. The average content of carbonates, organic matter and mineral parts for this layer are, respectively: 9%, 8% and 83%. The Holocene period begins with an about 30-cm layer of dark-grey non-carbonate detritus-mineral gyttja consisting solely of organic matter (approximately of 57%) and mineral matter (43%). The next deposits in the profile are pre-Boreal, Boreal and Atlantic, light-cream carbonate gyttja with approximately 35-50% content of carbonates. The youngest part of the profile was not included in the palynological analyses. In 2012 two more sediment cores were collected from this part of the lake. They are included in the geochemical and paleobiological analyses.

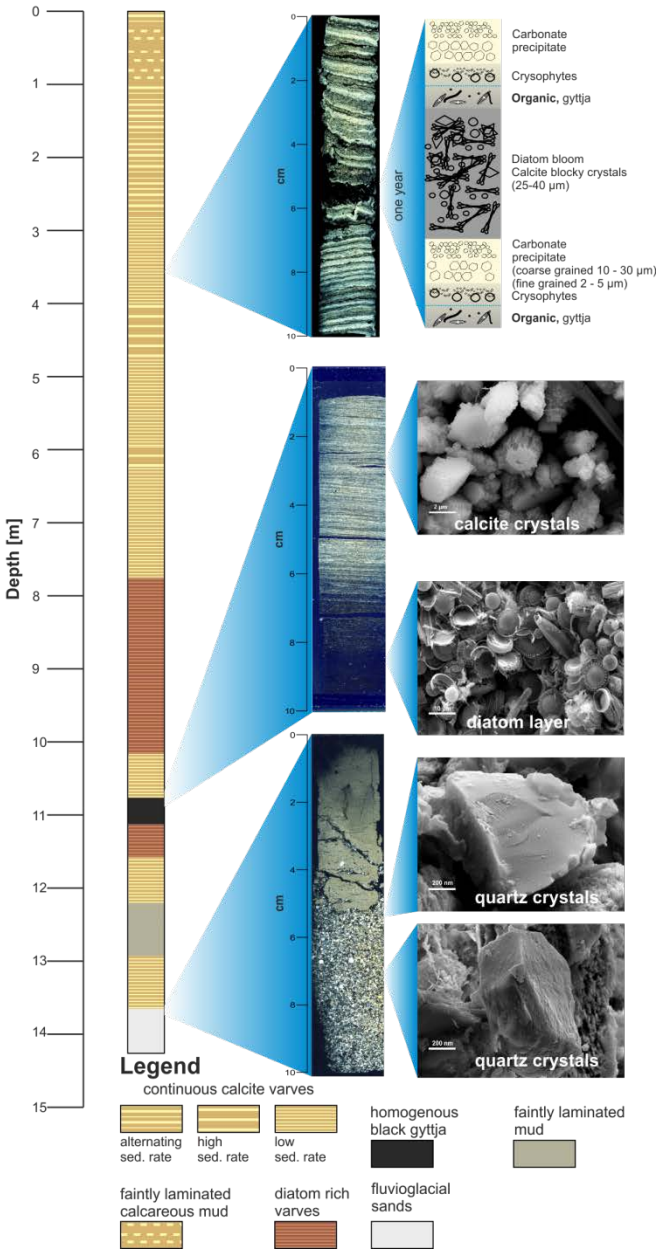

Fig 6. Master composite profile mainly composed of annually laminated (varved) lake sediments. Large petrographic thin section scans (10x 2x 1 cm) together with SEM pictures exhibit selected areas of (i) biogenic calcite varves (top), (ii) abrupt changes in varve preservation and sedimentological units (middle)

During September 2009 and May 2012 four parallel and overlapping series of long cores were retrieved with the longest core reaching 14.25 m at 32 m water depth. From these core sequences a master composite profile has been established by means of defining lithological marker layers at macroscopic and microscopic scales (Fig. 6).

The key aspect of the Czechowskie lake sediments is the very well preserved annually laminations (varves) covering 88 % of the entire profile. Thus makes the lake sediments a valuable and unique archive for past climate and environmental reconstructions for the Northern Polish Lowlands. Detailed investigations have been carried out for the last 2000 years of the sediment profile applying micro-facies analyses. The chronology has been established by a multiple dating approach with varve counting, AMS 14C on plant macro remains and 137Cs activity measurements. Micro-facies analyses reveal that the sediment consists of biogenic calcite varves with intercalated diatom rich layers. Distinct 100 to 200 years long periods of up to threefold thicker varves (approx. 1.4 to 5.0 mm/year) are predominantly caused by an increase in the diatom sub-layers and indicate distinct short-term climatic and environmental fluctuations. Possible reasons for these changes that occurred abruptly with only few years are either changes in lake water circulation or in nutrient supply to the lake.

Within the frame of ICLEA and together with Lake Tiefer See Klocksin situated in Northern Germany, one objective is to investigate natural archives in a landscape extending from northeastern Germany to northwestern Poland. Both lakes offer a direct comparison up to seasonal resolution and due to the simultaneous lake monitoring a direct link to calibrate proxy against instrumental data.

Hydrological research

In hydrographic terms Lake Czechowskie is located in the basin of the Wda – a left bank tributary of the lower Vistula. The catchment of Lake Czechowskie is located in the central part of the basin. Its topographic surface area is 19.76 km^2. The north-eastern border of the Lake Czechowskie catchment is also a watershed between the basins of the Wierzyca and Wda. Multi-year (1974-2003) average unit discharge for the catchment section of the Wda up the water gauge of Czarna Woda is approximately 6 $dm^3s^{-1}km^{-2}$.

Czechowskie Lake is a flow lake. The main tributary to the lake is a watercourse flowing from Lake Głęboczek located at the elevation of 117 m. Next, it drains a peat depression of the paleolake Trzechowskie situated at the elevation of approximately 110.5 m. Further on, it enters the lake in its western part. Flow measurement made in July 2012 showed that 9 dm^3s^{-1} of water got into the lake. In addition to the main tributary to Lake Czechowskie there are also two small watercourses draining old lake bays: to the NW of the lake and from the village Piece (in July 2012 the flow rate was approximately 6 dm^3s^{-1}). Currently, all surface watercourses are regulated and collect water from drainage systems. The outflow from the lake is in its eastern part. This watercourse runs into the Wda, below the village of Młyńsk, at the elevation of about 101 m. The total length of the watercourse, with the lake forming the hydrographic axis of the catchment, is 4.76 km.

The main purpose of the hydrological and hydrogeological studies was to determine the alimentation conditions and water circulation within the studied river-lake system. Thus, in 2012, a network of piezometric stations was set up around Lake Czechowskie, which included 18 piezometric holes (Fig. 7). Drilling depth for piezometers ranged from 3 to 19 m. In all drillings there were sandy and sandy-clayey deposits, and only in three drillings there was a sandy clay insertion. In the majority of the holes the ceiling of impermeable deposits was not reached. Free water table stabilised at the level not less than 1.5 m above

the bottom of the piezometer. The ordinates of the ground surface around the piezometers were determined using RTK GPS.

Since May 2012, seven series of the underground water table measurements were carried out. At that time the amplitude of the position of the water table in most piezometers was at about 70 cm. A similar course and scope of changes in the position of water table was observed in all piezometric holes. This demonstrates the dependence of water levels on pluvial conditions, and thus the same aquifer is observed. The largest fluctuations in the groundwater levels were observed in one of the shallow piezometers – No. 13, with a depth of 2.93 m – located on the lake terrace to the SW of the lakeshores. In the study period the amplitude of the position of the water table in this hole exceeded 1 m.

In July 2012, a hydrographic survey of the first groundwater level around the lake was carried out. The height difference of the water table in this small area was over 12 m (from 117.77 to 105.27 m). Measurements of the position of the water table in 80 wells located in the surroundings of the lake and monitoring of water levels in the network of piezometers made it possible to determine the underground catchment of Lake Czechowskie. The main direction of the underground drainage is W-E.

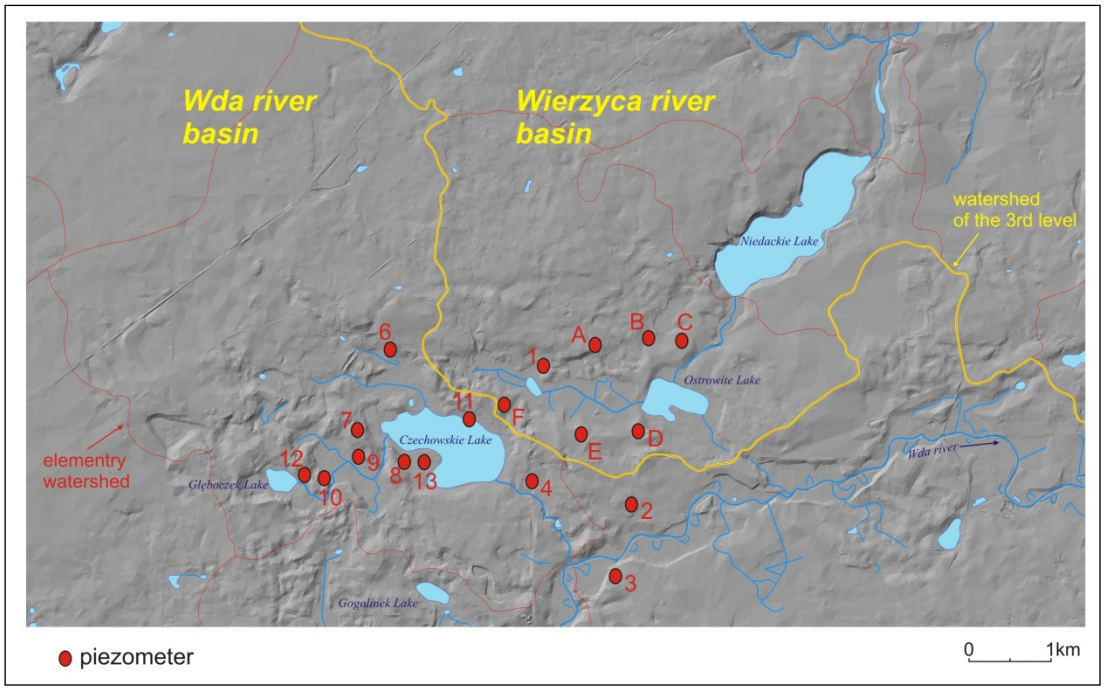

Fig. 7. Localization of the piezometers in the Czechowskie Lake vicinity.

For the 2013 season it is scheduled to start flowing water monitoring in the catchment of Lake Czechowskie, on all tributaries and the main watercourse. In total, it is planned to set seven gauge stations to conduct the flow rate measurements at monthly intervals. In parallel with the hydrometric and hydrogeological measurements, studies on physico-chemical properties of groundwater and surface water will be carried out. Water samples will be collected in order to identify the salinity parameters and contents of biogenic substances.

Limnological research

In May 2012 on the north shore of the lake a gauge station was set up to observe the water levels in Lake Czechowskie. The average level of water in the lake, determined on the basis of the measurements, was 109.84 m. In the second half of 2012 water level in the lake fluctuated from 109.38 (August) to 110.13 m (May). The amplitude of the lake water fluctuations in the second half of 2012 was thus 0.75 m, which is the typical of flow lakes in Poland.

Measurements of the vertical temperature variation were carried out in the deepest part of the lake. From July to November five measurement series were carried out to determine the thermal stratification of the lake. During this period, the disappearance of summer stratification was captured. The depth of epilimnion gradually increased each month from 5 m in July to 9 meters in October. At the same time, its temperature dropped from 19.6 to 10.6°C. The metalimnion, most fully developed in July, included the water layer of 3 m in thickness. It was characterised by a large drop in temperature, which was 3.5°C per meter. In the whole period the temperature of the hypolimnion water was from 6.0 to 6.1°C. In the last series of measurements before freezing, conducted on the 20th November, the autumn mixing of lake water was recorded. The difference between the water temperature at the surface, which was 6.1°C, and near bottom water temperature was only 0.1°C. On the basis of previous measurements of the thermal regime characteristics indicate the bradimictic nature of the water circulation in Lake Czechowskie.

Lake Czechowskie has not so far been analysed in terms of its detailed oxygen regime. One-time measurement of variation of oxygen vertical concentration in the deepest part of the lake was conducted by Gwoździński and Kilańczyk (2009) in March and September 2008. During the spring circulation the oxygen content was aligned vertically and was 15.7 mg $O_2 \cdot dm^{-3}$ at the water temperature of 3.9-4.0°C. Measurements carried out during the summer water stagnation showed a clinograde oxygen curve. In the epilimnion layer, to a depth of 7 m, its concentration did not change significantly and was about 12 mg $O_2 \cdot dm^{-3}$ (water temperature of 20.2°C). Further below, the oxygen contents decreased rapidly, at first to 3.3 mg $O_2 \cdot dm^{-3}$ at a depth of 12 m, then slowly to 2.2 mg $O_2 \cdot dm^{-3}$ at a depth of 26 m. One metre above the bottom (31 m) the dissolved oxygen concentration was only 1 mg $O_2 \cdot dm^{-3}$.

Starting from the spring season 2013 it is scheduled to continue measuring the thermal variation of water in the deepest part of the lake in a monthly cycle. The study will also be complemented by measurements of the temperature variation in the secondary deep of the lake. In parallel with the temperature, measurements of the dissolved oxygen concentration in the water and of conductivity values will be carried out. In addition, water samples will be collected for chemical analyses. Water samples will be analysed in terms of the content of basic ions and biogenic substances.

Land use in the catchment of Lake Czechowskie

Today, the surface of the catchment of Lake Czechowskie, occupying almost 20 km^2, in more than 60% is covered by forests (12 km^2). It is primarily a pine monoculture. The largest dense forest complexes are located in the western and southern parts of the catchment, while the northern part is used for agricultural purposes, or is a built-up area. Today, the lake is almost completely surrounded by woods and wetlands with a belt at least 0.5 km wide.

In order to reliably assess changes in the distribution of forests the oldest available cartographic materials were used, namely the Schroetter Maps which present the situation in the area at the end of the

18th c. Made in a scale of approximately 1:50 000, they are the first cartometric maps to the area although not devoid of errors.

The picture of the land use presented in the above map is in large measure similar to the modern one. The area occupied by forests was then approximately 50% of the catchment area. The differences in the vegetation cover, compared to the situation today, are observed to the south and south-east of Lake Czechowskie – these areas were then covered with forest.

However, distinct changes are observed in the cartographic materials from 1874s (Messtischblatt maps of 1:25 000). Since the end of the 18th c. a significant deforestation took place within the catchment. Tree felling occurred mainly in the eastern and south-eastern parts of the catchment. Since then the forested area has increased by 35%.

Human activity within the catchment of Lake Czechowskie, shown in the analysed cartographic materials, is also reflected by the drainage work done on peatland and the construction of weirs located at the outlet of Lake Czechowskie near its mouth to the Wda, allowing adjustment of the outflow from the lake.

Stop 3 Wygonin – record of periglacial and anthropogenic transformation in soil profiles

One of the most characteristic forms of the marginal zone of the Pomeranian Phase near Stara Kiszewa is a sedimentational edge of the ice contact, representing the proximal part of the high outwash level. It runs roughly along the line of lakes Wygonin and Chwarzno and further to the east to the settlement of Okoninki (Fig. 2). Elevations in the root zone of the outwash reach up to 155 m and gradually decrease towards the south. This is the highest surface of the proglacial outflow in this region. From the north, it is adjacent to two major depressions: a melt-out basin of Lake Krąg and a terminal-like depression to the east of Stara Kiszewa. The surface of the high outwash plain is separated from the above forms with the edge of the relative heights of up to 15 m. The edge is very clearly visible in the vicinity of Lake Wygonin. In other places, particularly where the high outwash level contacts with the sections of the lowered outwash surface, it has more the character of a small transition zone with a number of edges and flattenings rather than a linear form.

The morphology of the proximal part of the outwash plain is extremely varied. There are a number of melt-out and channel depressions, among which a large channel of Lake Wygonin stands out. Only south of Lake Wygonin the high outwash plain surface is more compact and slopes towards the south-west. From the west and south the high outwash plain level is cut with an erosive edge of 5-7 m, below which there is the Wda outwash level associated with the proglacial outflow from the vicinity of Kościerzyna.

On the basis of drillings in the proximal part of the high outwash level it can be demonstrated that its structure is dominated by sandy-gravel-boulder deposits reaching up to 10 m in thickness. Simultaneously, in the drilling profiles located along the cross-section lines extending from the sedimentation edge of the ice contact towards the south a systematic decrease in the gravel-boulder fraction is observed.

The analysis of geological structure and geomorphological situation indicates that the root part of the high outwash level can be defined as the sedimentation edge of the ice contact. The accumulation of the edge zone of high outwash level took place under the conditions of a relatively long and stable support by the ice sheet edge. The deposition took place mainly with the participation of supraglacial water as indicated by the presence, in some parts of the hinterland, of the edge of the high outwash level reduced by about 5-20 m of the outwash surface. At the same time, there are a number of subglacial channels

associated with the sedimentation edge of the ice contact as well as an esker form, which suggests that in its initial stage of the development an important role was played by subglacial drainage, both of the N and R types.

After its accumulation, the surface of the high outwash level was relatively long under periglacial conditions that led to the development of permafrost, probably of the discontinuous nature. It is particularly indicated by the signs of the presence of the active permafrost layer recorded in the soil profile, as well as a large number of ventifacts on the surface of the high outwash level.

Studies of the course of the beginning of the lacustrine sedimentary sequence in the terminal depression near Stara Kiszewa and in the surrounding lake basins (Błaszkiewicz 2005a) allow us to infer about the duration of the periglacial conditions to the cold periods of the Late Glacial. At the same time, it can be specified that the final degradation of permafrost in this area took place only at the end of the pre-Boreal.

Soil development near Wygonin

The Wygonin site is situated at the northern end of a southward dipping outwash plain. To the north, the outwash plain is flanked by a northwest striking subglacial valley. A stone line with ventifacts, 60 cm below the surface, hints to post-depositional periglacial superimposition. On the outwash plain a *Braunerde* with a 12 cm (10YR 3/2, dark brown) humic topsoil and a 60 cm brunified horizon (7.5YR 5/8, strong brown) is developed (Fig. 8). Soil development at the northern slope to the subglacial valley is only weak. At the toeslope however, similar pedologic features compared to the outwash plain are found, though the *Braunerde* is covered by an 85 cm thick colluvial fan (Fig. 8). Soil genesis in the colluvial fan is restricted to the enrichment of organic material. ^{14}C datings of charcoal particles collected from the colluvial fan hint to a translocation of the colluvial deposits during the last three centuries.

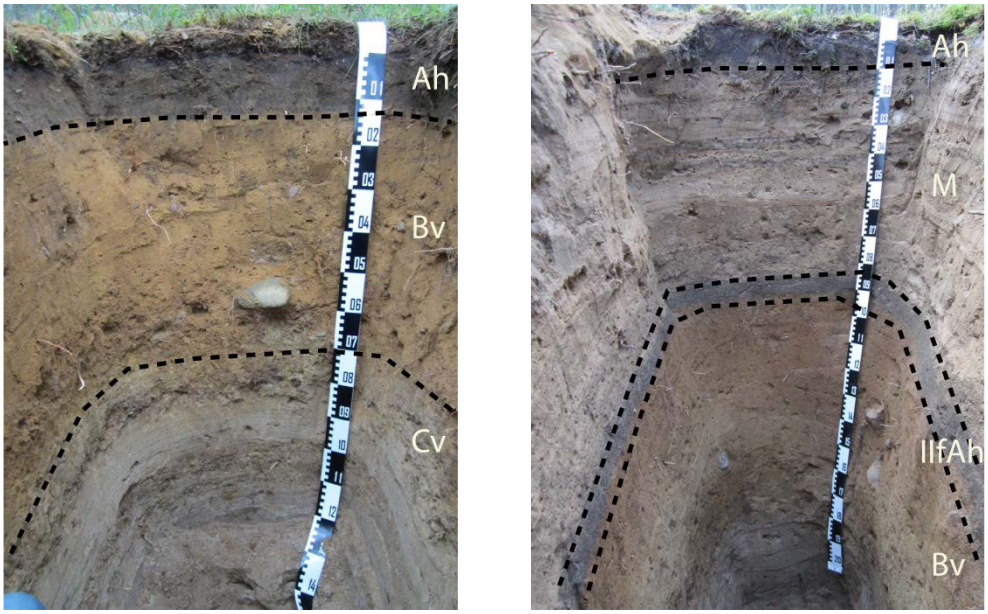

Fig. 8. Left: Braunerde on the outwash plain with stone line 60 cm below the surface. Right: Fossilized Braunerde under an 85 cm thick colluvial fan.

Acknowledgements

This study is a contribution to the Virtual Institute of Integrated Climate and Landscape Evolution (ICLEA) of the Helmholtz Association and National Science Centre, Poland (grant No. 2011/01/B/ST10/07367).

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Figures

Fig. 1: Map of Poland with the location of the ICLEA trips area and maximum extent of the Late Vistulian ice sheet (after Kozarski, 1975). L = Leszno phase (Brandenburgische Stadium); P = Poznań phase (Frankfurter Eisrandlage); Pm = Pomeranian phase; Ga = Gardno phase.

Fig. 2: Geomorphological sketch of the western and central part of the Starogardzkie Lakeland (map sheets of Stara Kiszewa, Zblewo and Osiek SzMGP 1: 50 000 – Błaszkiewicz 2005 b,c; 2006). 1 – morainic plateau; 2 – drumlin forms; 3 – high glacial outwash plain level; 4 – other glacial outwash plains; 5 – areas of kame fill-up; 6 – kame hummocks and hills; 7 – eskers; 8 – kame terraces; 9 – subglacial channels; 10 – kettles; 11 – sedimentation edge of the ice contact of the high outwash plain level; 12 – river valleys; 13 – river terraces; 14 – alluvial fans; 15 – erosive edge of the high outwash plain level; 16 – pre-Alleröd lake level at the end depression near Stara Kiszewa, 17 – biogenic plain; 18 – dunes; 19 – aeolian sand plain; 20 – presumable course of the Pomeranian phase; 21 – research sites.

Fig. 3: Cross-section trough the bottom of a depression near Stara Kiszewa. 1 – till; 2 – sand; 3 – silt and sand/silt; 4 – mud/clay intraclasts; 5 – gyttja; 6 – lacustrine chalk; 7 – malacofauna; 8 – faults; 9 – borehole.

Fig. 4: Morphological sketch of the Czechowskie Lake vicinity

Fig. 5: Exemplary cross section through limnic and telmatic sediments of the Czechowskie Lake biogenic plain developed in the west side of the recent waterbody

Fig. 6: Master composite profile mainly composed of annually laminated (varved) lake sediments. Large petrographic thin section scans (10x 2x 1 cm) together with SEM pictures exhibit selected areas of (i) biogenic calcite varves (top), (ii) abrupt changes in varve preservation and sedimentological units (middle) and (iii) initial lake development (bottom).

Fig. 7: Localization of the piezometers in the Czechowskie Lake vicinity.

Fig. 8: Left: Braunerde on the outwash plain with stone line 60 cm below the surface. Right: Fossilized Braunerde under an 85 cm thick colluvial fan.

List of participants - 2nd ICLEA-Workshop 2013

Abbreviations of institutions:
***IG PAS** = Institute of Geography and Spatial Organization, Polish Academy of Sciences, research unit Toruń, research unit Warsaw, research unit Cracow (PAN), Poland*
***GFZ** = Helmholtz Centre Potsdam - German Research Centre for Geosciences, Potsdam, Germany;*
Section 1.4 Remote Sensing; Section 5.2 Climate Dynamics and Landscape Evolution; Section 5.4 Hydrology; Section wVB Scientific Executive Board
***BTU Cottbus** = Brandenburg University of Technology*
***University of Greifswald**: **IBL** = Institute of Botany and Landscape Ecology, **IGG** = Institute for Geography and Geology, Greifswald, Germany*
***IG UKW** = Kazimierza Wielkiego University of Bydgoszcz, Institute for Geography, Bydgoszcz, Poland*
***IGS PAS** = Institute of Geological Sciences, Polish Academy of Sciences, Warsaw, Poland*
***LBGR** = Landesamt für Bergbau, Geologie und Rohstoffe Brandenburg, Dezernat Bodengeologie, Cottbus, Germ.*
***LUNG MV** = Landesamt für Umwelt, Naturschutz und Geologie, state Mecklenburg-Vorpommern, Güstrow, Germany*
***NAS Belarus** = National Academy of Sciences of Belarus, Institute for Nature Management*
***PGI** = Polish Geological Institute, National Research Institute, Warsaw; PGI Marine Geology Branch, Gdańsk, Poland*
***WSL** = Swiss Federal Institute for Forest, Snow and Landscape Research*

Name, Surname	Institution	Email	ICLEA WP
Andrzejewski, Leon	University of Toruń	leon@umk.pl	
Badziai, Vitali		bodv@rambler.ru	
Baranowski, Jarosław	IG PAS Warsaw	j.bar@twarda.pan.pl	
Bauriegel, Albrecht	LBGR Cottbus	Albrecht.Bauriegel@lbgr.brandenburg.de	5
Błaszkiewicz, Mirosław	IG PAS Toruń	mirek@geopan.torun.pl	5
Blome, Sandra	University of Greifswald, IBL		3
Blume, Theresa	GFZ, Sect. 5.4	blume@gfz-potsdam.de	1
Börner, Andreas	LUNG M-V	Andreas.Boerner@lung.mv-regierung.de	4
Brademann, Brian	GFZ, Sect. 5.2	brademan@gfz-potsdam.de	4
Brauer, Achim	GFZ, Sect. 5.2	brau@gfz-potsdam.de	4
Brykała, Dariusz	IG PAS Toruń	darek@geopan.torun.pl	5
Buras, Allan	University of Greifswald, IBL	allan@buras.eu	3
Burmester, Hannah	University of Greifswald, IBL		3
Degórski, Marek	IG PAS Warsaw	m.degor@twarda.pan.pl	
Dietze, Elisabeth	GFZ, Sect. 5.2	edietze@gfz-potsdam.de	5
Dräger, Nadine	GFZ, Sect. 5.2	ndraeger@gfz-potsdam.de	5
Dreibrodt, Janek	GFZ, Sect. 5.4	dreibrod@gfz-potsdam.de	1
Frantiuc, Alexandru	BTU Cottbus	frantiuc.alexandru@gmail.com	5
Froehlich, Wojciech	IG PAS Cracow	wfroehlich@pro.onet.pl	
Fojutowski, Michał	IG UKW Bydgoszcz		
Gamrat, Wojciech	University of Toruń	wojgam@o2.pl	
Gierszewski, Piotr	IG PAS Toruń	piotr.gierszewski@geopan.torun.pl	
Górny, Michał	IG UKW Bydgoszcz		
Güntner, Andreas	GFZ, Sect. 5.4	guentner@gfz-potsdam.de	1
Heidbüchel, Ingo	GFZ, Sect. 5.4	ingo.heidbuechel@gfz-potsdam.de	1
Heinrich, Ingo	GFZ, Sect. 5.2	heinrich@gfz-potsdam.de,	3
Hirsch, Florian	BTU Cottbus	hirschf@tu-cottbus.de	5
Itzerott, Sibylle	GFZ, Sect. 1.4	itzerott@gfz-potsdam.de,	2
Jędrzejewski, Łukasz	IG UKW Bydgoszcz		
Kaiser, Knut	GFZ, Sect. wVB	kaiser@gfz-potsdam.de	4
Karasiewicz, Tomasz M.	University of Toruń	mtkar@uni.torun.pl	
Kienel, Ulrike	GFZ, Sect. 5.2	ukienel@gfz-potsdam.de	4
Kleine, Iris	GFZ, Sect. 1.4	ikleine@gfz-potsdam.de	2
Kolstrup, Else	University of Uppsala, Sweden	Else.Kolstrup@natgeog.uu.se	SAB

Kordowski, Jaroslaw	IGiPZ PAN Toruń	jaroslaw.kordowski@geopan.torun.pl	5
Kramkowsk,i Mateusz	IG UKW Bydgoszcz	mateusz_k@tlen.pl	
Krupa, Adam	IG UKW Bydgoszcz	akrupa@ukw.edu.pl	
Krzymińska, Jarmila	PGI Gdańsk	jarmila.krzyminska@pgi.gov.pl	
Küster, Mathias	University of Greifswald, IGG	mathias.kuester@uni-greifswald.de	4,5
Łachacz, Andrzej	University of Olsztyn	andrzej.lachacz@uwm.edu.pl	
Lamparski, Piotr	IG PAS Toruń	piotr@geopan.torun.pl lampka@gmail.com	
Lampe, Reinhard	University of Greifswald, IGG	lampe@uni-greifswald.de,	4
Lorenz, Sebastian	University of Greifswald, IGG	sebastian.lorenz@uni-greifswald.de	4
Lutyńska, Monika	University of Poznań	lutynska@amu.edu.pl	4,5
Mirosław-Grabowska, Joanna	IGS PAS Warsaw	jmirosla@twarda.pan.pl	
Motagh, Mahdi	GFZ, Sect. 1.4	motagh@gfz-potsdam.de	2
Negendank, Jörg F.W.	University of Potsdam	negda@gmx.de	SAB
Nikolay, Alexander	BTU Cottbus	Alexander.Nicolay@tu-cottbus.de	5
Noryśkiewicz, Agnieszka	University of Toruń	anorys@umk.pl	
Noryśkiewicz, Bożena	University of Toruń	norys@umk.pl	
Obremska, Milena	IGS PAS Warsaw	mobremska@twarda.pan.pl	4,5
Orzechowski, Mirosław	University of Olsztyn	miroslaw.orzechowski@uwm.edu.pl	
Ott, Florian	GFZ, Sect. 5.2	ottflo@gfz-potsdam.de	4
Raab, Thomas	BTU Cottbus	raab@tu-cottbus.de	5
Rychel, Joanna	PGI Warsaw	joanna.rychel@pgi.gov.pl	
Scharnweber, Tobias	University of Greifswald, IBL	tobias.scharnweber@uni-greifswald.de	3
Schneider, Anna	BTU Cottbus	schneida@tu-cottbus.de	5
Schulz, Deborah	Freie Universität Berlin	deborah.schulz@fu-berlin.de	5
Schwab, Markus J.	GFZ, Sect. 5.2	mschwab@gfz-potsdam.de	4
Schwank, Mike	WSL, Switzerland	mike@schwank.ch	2
Slowinski, Michal	IG PAS Toruń / GFZ Sect. 5.2	slomich@wp.pl michal.slowinski@gfz-potsdam.de	1,4
Simard, Sonia	GFZ, Sect. 5.2	simard@gfz-potsdam.de	3
Smólczyński, Sławomir	University of Olsztyn	slawomir.smolczynski@uwm.edu.pl	
Takla, Melanie	BTU Cottbus	melanie.takla@tu-cottbus.de	5
Tecklenburg, Christina	GFZ, Sect. 5.4	ctecklen@gfz-potsdam.de	1
Theuerkauf, Martin	University of Greifswald, IGG	martin.theuerkauf@uni-greifswald.de	4
Tylmann, Wojciech	University of Gdańsk	geowt@ug.edu.pl	
Tyszkowski, Sebastian	IG PAS Toruń	sebastian.tyszkowski@geopan.torun.pl sebtys@wp.pl	
Wilke, Henriette	GFZ, Sect. 5.4	wilke@gfz-potsdam.de	1
Wilmking, Martin	University of Greifswald, IBL	wilmking@uni-greifswald.de	3
Wulf, Sabine	GFZ, Sect. 5.2	swulf@gfz-potsdam.de	4
Zawiska, Izabela	IG PAS Warsaw	ikrajewska@twarda.pan.pl	4

(last update April 12, 2013)

ISSN 1610-0956