

# Geochronometria

Conference Abstracts Series

Volume 2

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**13<sup>th</sup> International Conference**  
**"METHODS OF ABSOLUTE CHRONOLOGY"**  
**5-7<sup>th</sup> June 2019**  
**Tarnowskie Góry, Poland**



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**2019**

# **Geochronometria**

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**ISBN 978-83-904783-4-0**

**Institute of Physics – CSE**

**Silesian University of Technology**

**Gliwice, Poland**

**2019**



**13<sup>th</sup> International Conference**  
**“METHODS OF ABSOLUTE CHRONOLOGY”**

5-7<sup>th</sup> June 2019  
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# ABSTRACTS & PROGRAMME

## Conference organisers

 <p>Gliwice Absolute DAting Methods Centre Division of Radioisotopes Institute of Physics - Centre for Science and Education Silesian University of Technology Konarskiego 22B, PL-44-100 Gliwice, Poland <a href="http://www.carbon14.pl/">http://www.carbon14.pl/</a></p>	 <p>The Committee for Quaternary Research Polish Academy of Sciences Institute of Geological Sciences ul. Twarda 51/55, PL-00-818 Warsaw, Poland <a href="http://www.kbcz.pan.pl/">http://www.kbcz.pan.pl/</a></p>
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*Ghent University, Belgium*

## Conference venue

“Opera Hotel”

Zamkowa 1, 42-600 Tarnowskie Góry, Poland

## 13<sup>th</sup> International Conference "Methods of Absolute Chronology" Tarnowskie Góry 5-7<sup>th</sup> June 2019

### Overview of the Conference Programme

Wednesday 5 <sup>th</sup> June	Thursday 6 <sup>th</sup> June	Friday 7 <sup>th</sup> June
<b>8:30 -10:00</b> Registration / welcome coffee	<b>8:15 - 9:00</b> Lecture OSL	<b>8:15 - 9:00</b> Lecture <sup>14</sup> C
<b>10:00-10:20</b> Conference opening	<b>9:00 - 10:20</b> Session 4: OSL methods	<b>9:00 - 10:40</b> Session 6: <sup>14</sup> C methods / Speleothems
<b>10:20 - 11:00</b> Introductory lecture	<b>10:20 - 11:50</b> Poster session no. 2 / Coffee	<b>10:40 - 11:40</b> Poster session no. 3 / Coffee
<b>11:00 - 12:40</b> Session 1: Mortars	<b>11:50 - 13:30</b> Session 5: OSL- applications	<b>11:30 -13:00</b> Session 7: Tree-rings / Varia
Coffee	Lunch & coffee <b>13:30 - 14:30</b>	<b>13:00 -13:30</b> General discussion and conference closing
<b>13:10 - 14:30</b> Session 2: <sup>14</sup> C in Environment		Lunch and coffee
Lunch & coffee <b>14:30 - 15:30</b>		
Session 3: Archaeology <b>15:30- 17:10</b>	<b>15:00 - 19:00</b> Trip to the historic silver mine	
<b>17:30- 18:30</b> Poster session no.1 / Coffee		
<b>18:30 – 19:00</b> Duo Vitare concert <b>19:15</b> Ice breaking party	<b>20:00 - 22:00</b> Conference dinner	

# Conference programme

## Wednesday 5<sup>th</sup> June 2019

8:30 – 10:00 Registration & welcome coffee

10:00 – 10:20 Conference opening

10:20 – 11:00 Introductory lecture:

### INVITED SPEECH:

Time	Author	Title
10:20	Leszek Marks	Formal stratigraphic subdivision of the Quaternary

### SESSION 1: Mortars

Convener: Helena Hercman

Time	Authors	Title
11:00	Alf Lindroos, Thomas Schröder Daugbjerg, Jesper Olsen, Åsa Ringbom, Jan Heinemeier	Sample preparation tests for radiocarbon dating of mortars
11:20	Danuta Michalska	Sequential dissolution of carbonate rocks in context of mortars dating
11:40	Alf Lindroos, Åsa Ringbom, Jan Heinemeier, Jesper Olsen, Irka Hajdas	Radiocarbon dating of the Roman Mérida Amphitheater in W Spain. Challenges with an unusually hard and impermeable mortar
12:00	Irka Hajdas, Manuel Janosa	<sup>14</sup> C dating of mortar from ruins of an early Medieval church Hohenrätien GR, Switzerland

12:20	Giulia Tirelli, Stefano Lugli, Marta Caroselli, Anna Galli, Irka Hajdas, Alf Lindroos, Marco Martini, Francesco Maspero, Jesper Olsen, Laura Panzeri, Åsa Ringbom, Emanuela Sibia, Elena Silvestri	Dating earthquake damage of the Modena cathedral vaults (Northern Italy): an integrated approach
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12:40 – 13:10 Coffee break

## SESSION 2: <sup>14</sup>C in Environment

**Convener: Irka Hajdas**

Time	Authors	Title
13:10	Roman Nepop, Anna Agatova, Piotr Moska	To the problem of last large dammed lakes existence in intermountain depressions of the SE Altai, Russia
13:30	Anna Agatova, Roman Nepop, Maria Bronnikova, Yulia Konopliankova	Problems of applying radiocarbon analysis for dating contemporary and fossil soils within tectonically active mountain terranes (by the example of the SE Altai)
13:50	Piotr Szwarzewski, Jonas Mažeika, Ričardas Paškauskas, Ewa Smolska, Žana Skuratovič, Olga Jefanova	Dating the Nemunas delta progradation - a multiproxy approach
14:10	Tatiana Pampura, Olga Zarubina, Markus Meili	Effect of dating model on a peat-based reconstruction of Pb deposition history

14:30 – 15:30 Lunch



### SESSION 3: Archaeology

Convener: Alf Lindroos

Time	Authors	Title
15:30	Peter Barta, Jana Mellnerová Šuteková	Absolute Chronology of Baden: Radiocarbon changes the narrative?
15:50	Marek Nowak, Stanisław Wilk, Marcin M. Przybyła	Absolute chronology of the Early Eneolithic units in Lesser Poland. A discourse between pure radiocarbon and context-conditioned dating
16:10	Kęstutis Peseckas, Gytis Piličiauskas, Elena Pranckėnaitė, Simona Matuzevičiūtė, Rokas Vengalis, Jonas Mažeika, Žana Skuratovič	Ancient logboats in Lithuania: new finds, wood species and chronology
16:30	Tomasz Chmielewski, Agata Hałuszko, Tomasz Goslar, Sven Brummack, Olivia Cheronet, Tamás Hajdu, Tamás Szeniczey, Cristian Virag	Stratified sampling of human remains for accurate <sup>14</sup> C dating. Chronometric studies on Eneolithic burials discovered in Mikulin 9 (Poland) and Urziceni-Vamă (Romania)
16:50	Jan Petřík, Libor Petr, Katarína Adameková	First steps in dating of Celtic fields in the Czech Republic

17:30 – 18:30 Poster session no. 1/ coffee break

18:30 – 19:00 *Duo Vitare* – cello & guitar concert

19:15 – Ice-breaking party

## Thursday 6<sup>th</sup> June 2019

8:15 – 9:00 Lecture

### Lecture

Time	Author	Title
8:15	Grzegorz Adamiec	Optically stimulated luminescence dating using quartz

### SESSION 4: OSL-methods

Convener: Dimitri Vandenberghe

Time	Authors	Title
9:00	Alicja Chruścińska, Piotr Palczewski, Tomasz Rerek	SAR protocol using thermally modulated OSL (TM-OSL) of quartz
9:20	Konrad Tudyka, Sebastian Miłosz, Aleksander Kolarczyk, Grzegorz Adamiec, Andrzej Bluszcz, Grzegorz Poręba, Piotr Moska	Environmental radioactivity and dose rate measurement with the $\mu$ Dose system
9:40	Grzegorz Poręba, Konrad Tudyka, Aleksander Kolarczyk, Agnieszka Szymak	Problems with precise determination of dose rate in luminescence dating with $\gamma$ spectrometry due to the $^{222}\text{Rn}$ leakage
10:00	Tamás Bartyik, György Sipos, Gergő Magyar	Quartz luminescence sensitivity of fluvial and aeolian samples in the Panonian Basin

10:20 – 11:50 POSTER SESSION no. 2 / Coffee break

## SESSION 5: OSL-applications

**Convener: Alicja Chruścińska**

Time	Authors	Title
11:50	Zdzisław Jary, Piotr Moska, Marcin Krawczyk, Jerzy Raczyk, Jacek Skurzyński	Revision of the Late Pleistocene loess-palaeosol stratigraphy in Poland
12:10	Jacek Skurzyński, Zdzisław Jary, Piotr Moska, Jerzy Raczyk	The variations in chemical composition of the L1LL1 loess unit in context of age-depth model and spatial distribution – case of Biały Kościół and Tyszowce sections (Poland)
12:30	György Sipos, Orsolya Tóth, Tímea Kiss, Tamás Bartyik, Dávid Filyó, Gábor Mezősi	OSL dating of terrace and floodplain development along the Hungarian Lower Danube
12:50	Nasrin Karimi Moayed, Jan Bastiaens, Paulina Biernacka, Ann-Eline Debeer, Wim De Clercq, Koen Deforce, P. De Smedt, E. Ghyselbrecht, D. Vandenberghe, J. De Grave	Developing a temporal framework for past natural resource exploitation in the Sonian Forest using optically stimulated luminescence dating
13:10	Piotr Moska, Zdzisław Jary, Grzegorz Poręba, Konrad Tudyka, Jerzy Raczyk, Marcin Krawczyk, Jacek Skurzyński, Adam Michczyński, Grzegorz Adamiec, Natalia Piotrowska, Fatima Pawełczyk, Agnieszka Szymak, Kamila Ryzner	Stratigraphic aspects of inland dune formation on Niemodlin Plateau (SW Poland)

13:30 – 14:30 Lunch

15:00 – 19:00 Trip to the historic silver mine in Tarnowskie Góry (UNESCO heritage site)

20:00 – 22:00 Conference dinner & pianist performance

## Friday 7<sup>th</sup> June 2019

8:15 – 9:00 Lecture

### Lecture

Time	Author	Title
8:15	Andrzej Z. Rakowski	Everything you always wanted to know about radiocarbon* (*but were afraid to ask)

### SESSION 6: <sup>14</sup>C methods / Speleothems

Convener: Peter Barta

Time	Authors	Title
	<u>Invited speech:</u>	
9:00	Matthias Hül	Radiocarbon dating of iron artefacts
9:20	Jacek Pawlyta	Some problems of isotopic fractionation correction in radiocarbon dating and other <sup>14</sup> C applications
9:40	Jacek Pawlak, Helena Hercman, Marcin Błaszczuk, Paula Sierpień, Bartosz Wach	Estimation of age duration for depositor breaks (hiatuses)
10:00	Marcin Błaszczuk, Helena Hercman, Jacek Pawlak	Paleoclimate reconstruction for MIS 9 - MIS 7 period basing on speleothems records from selected caves in Tatra Mts. (Poland)
10:20	Jacek Pawlak, Helena Hercman, Marcin Błaszczuk, Paula Sierpień, Bartosz Wach	Last Glacial/Holocene transition recorded in the speleothem from the Demianova cave system (Slovakia)

10:40 – 11:40 Poster session no. 3 / coffee break

## **SESSION 7: Tree-rings / Varia**

**Convener: Matthias Hüls**

<b>Time</b>	<b>Authors</b>	<b>Title</b>
11:40	Tiberiu Bogdan Sava	Inter-validation of dendrochronology and $^{14}\text{C}$ dating on a tree-ring sequence of 700 years originating from Eastern Carpathians
12:00	Sławomira Pawełczyk	Air pollution by sulfur dioxide on the basis of carbon isotopes in tree rings – case study for Sudeten, Tatras and Suwałki region in Poland
12:20	Libor Petr	Neolithic wooden wells from Czech Republic, dating and their importance for landscape reconstruction
12:40	Jacek Pawlyta, Andrzej Rakowski	$^{14}\text{C}$ excursions in the available radiocarbon time-series

13:00 – 13:30 General discussion and conference closing

13:30 – 14:30 Lunch & coffee

## **POSTER PRESENTATIONS**

## 5<sup>th</sup>-7<sup>th</sup> June 2019

**5<sup>th</sup> June 2019, 17:30 – 18:30 POSTER SESSION no. 1**

**6<sup>th</sup> June 2019, 10:20 – 11:50 POSTER SESSION no. 2**

**7<sup>th</sup> June 2019, 10:40 – 11:40 POSTER SESSION no. 3**

No	Authors	Title
1	Danuta Michalska, Małgorzata Szczepaniak, Małgorzata Mrozek-Wysocka, Andrzej Krzyszowski	Chronological study of archaeological site in Wilanowo versus environmental changes
2	Peter Barta, Michaela Dörnhöferová, Sylvia Bodoriková	Radiocarbon dating of archived bone samples from Gánovce–Hrádok: A contribution to the Holocene settlement history of the site
3	Adam Michczyński, Marian Rębkowski	A new statistical model of the chronology of the settlement Wolin , Trench 6/1660 based on radiocarbon dates, dendrochronological dating and stratigraphic and historic data.
4	Paweł Rutkiewicz, Ireneusz Malik	Dating of charcoal hearths and dam remnants associated with historical water-powered metallurgy (Southern Poland)
5	Natalia Piotrowska, Sławomira Pawełczyk, Jacek Tomczyk, Łukasz M. Staneczek	Radiocarbon AMS dating and stable CN isotope composition of Mesolithic human remains from Poland
6	Magdalena Kozicka, Grzegorz Osipowicz	Early Neolithic site in Trzciano – a case study about Mesolithic settling episode
7	Danuta J. Michczyńska, Piotr Gębica, Lucyna Wachecka-Kotkowska, Danuta Dzieduszyńska, Dariusz Krzyszkowski, Małgorzata Ludwikowska-Kędzia, Adam Michczyński, Leszek Starkel, Józef Superson, Dariusz Wieczorek	Interpleniglacial of Central and Southern Poland in the light of statistical analysis of radiocarbon and luminescence dates
8	Piotr Szwarczewski, Jonas Mažeika	Record of climate change and anthropopressure in Central Poland (a case study from Pacynka river valley in the vicinity of Radom)

9	Roman Nepop, Anna Agatova	Holocene radiocarbon chronology of debris flows in the eastern periphery of Chuya basin, SE Altai, Russia
10	Piotr Szwarczewski, Jonas Mažeika, Olga Jefanova, Žana Skuratovič, Anna Rogóż-Matyszczyk	Evaluation of the sedimentation rate of Czaple oxbow lake (Sieciechów area, central Poland)
11	Adam Michczyński, Daniel Okupny, Małgorzata Malkiewicz, Dominik Pawłowski, Małgorzata Ludwikowska-Kędzia, Jacek Forysiak, Sławomir Żurek	Late glacial palaeoenvironmental changes in the southern Holy Cross Mountains based on the “Białe Ługi” peatland record
12	Ilona Sekudewicz, Michał Gąsiorowski	Spatial distribution of $^{137}\text{Cs}$ in bottom sediments in Turawa and Koronowo lakes after 32 years since the Chernobyl power plant accident
13	Jarosław Sikorski	Pb-210 chronologies of young peat profiles sampled with low frequency
14	György Sipos, Christoph Schmidt, Dávid Filyó, Tamás Bartyik	Calibration transfer between alpha sources using different samples and protocols
15	Magdalena Biernacka, Piotr Palczewski, Alicja Chruścińska	Investigations of the traps responsible for OSL fast component in quartz using TM-OSL method
16	Zuzanna Kabacińska, Ryszard Krzyminiewski, Krzysztof Tadyszak, Emerson Coy	Generation of UV-induced radiation defects in calcite
17	Zuzanna Kabacińska, Danuta Michalska, Bernadeta Dobosz	Radiation defects in lime mortars and plasters studied by EPR spectroscopy
18	Piotr Palczewski, Alicja Chruścińska	Determination of electron trap parameters based on isothermal measurements performed using the TM-OSL method
19	Grzegorz Adamiec, Alicja Chruścińska, Piotr Moska, Piotr Palczewski	Luminescence properties of single grains of quartz
20	Grzegorz Poręba, Konrad Tudyka, Przemysław Mroczek, Piotr Moska, Jan Rodzik, Jerzy Raczek	Luminescence dating of Holocene soil erosion (Lublin Upland, E Poland): testing new approach to dose rate determination.



21	Robert Smyka, Magdalena Biernacka, Renata Majgier, Arkadiusz Mandowski	Luminescent properties of microcline from the granite pegmatite of the Strzegom Massif
22	Dimitri Vandenberghe, Ferdinand Messens, Marc De Batist, Johan De Grave	Luminescence dating of tsunami-laid sands in Lake Huelde (south-central Chile): methodology acknowledged
23	Nasrin Karimi Moayed, Patsy Billemon, Ann-Eline Debeer, Dimitri Vandenberghe, Johan De Grave	Luminescence characteristics of natural building stones from the Falcon Monastery (Antwerp, Belgium): potential for establishing (de)construction chronologies
24	Antoine Zink, Elisa Porto	The luminescence dating of the knight of Sarcus and the plommure finials from Beauvaisis province (France)
25	Edit Thamó-Bozsó, Gábor Csillag, Judit Fűri, Attila Nagy	Age of Danube terrace sediments on the Pest Plain (Hungary) based on optically stimulated luminescence dating of quartz and feldspar
26	Nikolai Tkach, Nikita Sychev, Radik Makshaev, Tamara Yanina	The first Middle Pleistocene absolute dates of the Middle Volga and the Northern Caspian regions
27	Kamila Ryzner, Piotr Moska, Grzegorz Poręba, Piotr Owczarek, Marcin Krawczyk, Piotr Szczypkowski	Palaeoenvironmental analysis of Nowolesie gully sediments (Niemcza-Strzeliń Hills, SW Poland)
28	Grzegorz Poręba, Ireneusz Malik, Małgorzata Wistuba, Beata Woskowicz-Ślęzak	Simultaneously using dendrochronology study and radioisotopes measurement to study soil erosion in loess gully near Poręba village (South Poland).
29	Łukasz Pawlik, Grzegorz Poręba, Natalia Piotrowska, Adam Michczyński	The geomorphological dynamics of the forested slope in the light of the activity level of $^{137}\text{C}$ , $^{210}\text{Pb}_{\text{ex}}$ and $^{14}\text{C}$ radioisotopes
30	Grzegorz Poręba, Zbigniew Śnieszko, Manfred Frechen	Simultaneously using Cs-137, Pb-210 and soil properties for the assessment of soil redistribution on an agricultural loess slope
31	Paula Sierpień, Helena Hercman, Jacek Pawlak, Pavel Bosák, Petr Pruner, Nadja Zupan-Hajna, Andrej Mihevc	The paleoclimate reconstruction based on oxygen and carbon stable isotopes records from flowstones in the Račiška pečina cave (SW Slovenia)
32	Helena Hercman, Jacek Szczygiał, Michał Gąsiorowski, Marcin Błaszczak	Caves as tools for reconstruction of relief changes in mountain areas – a case study from Tatra Mts.

33	Marcin Błaszczuk, Helena Hercman, Anna Mulczyk	Uranium concentrations and initial $^{234}\text{U}/^{238}\text{U}$ activity ratios in Demänova Cave System (Slovakia) and its significance for U-series dating and paleoclimate reconstructions
34	Helena Hercman, Michał Gąsiorowski, Pavel Bella, Michał Gradziński, Jacek Szczygiel, Pavel Bosák, Petr Pruner, Sarka Matoušková	Timing of active cave passages development and their relation to river terraces – a case study from the Demänová Caves System (Low Tatra Mts., Slovakia)
35	Alyssa Tate	Cob or Kernel: Considerations in the Radiocarbon Dating of Maize
36	Natalia Piotrowska, Fatima Pawełczyk	Status report from the AMS preparation line in the Gliwice Radiocarbon Laboratory, Poland
37	Marek Krąpiec, Andrzej Rakowski, Damian Wiktorowski, Matthias Huels	Status of the AMS graphitisation system in the Dendrochronological laboratory at AGH-Kraków
38	Andrzej Rakowski, Marek Krąpiec, Matthias Huels, Damian Wiktorowski, Jacek Pawlyta	Searching for abrupt increase of radiocarbon concentration in the past using annual tree rings
39	Andrzej Rakowski, Marek Krąpiec, Matthias Huels, Jacek Pawlyta, Damian Wiktorowski	Constructing of absolute dendrochronological scale for pine tree from Ujście (NW Poland)
40	Denisa Sedmáková, Ján Pittner, Jaroslav Vencurik, Milan Saniga	Relationship between stem damage, crown vitality and growth performance of European yew in Central-East Europe
41	Barbara Sensuła, Sławomir Wilczyński	Climate signal records in the ring width and stable isotopic composition of Scots pine in Silesia
42	Barbara Sensuła, Nathalie Fagel, Adam Michczyński, Nadine Mattielli	$\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ , radiocarbon, trace metal and Pb isotopic composition in Scots pine needles
43	Barbara Sensuła, Bartłomiej Toroń	Scanning electron microscopic analysis of trace elements deposition on the pine foliage
44	Elżbieta Szychowska-Krąpiec	Mediaeval traces of mining in the Sowie Mountains (Sudetes, SW Poland) in the light of radiocarbon and dendrochronological dating

45	Marek Krąpiec, Leonid Tymoshenko, Roman Myska, Elżbieta Szychowska-Krąpiec	Dendrochronological dating of St. George's orthodox church in Drohobych
46	Rūtilē Pukienē, Maris Zunde, Jonas Mažeika	Subfossil oaks from riverine sediments of two Latvian rivers: the first results of dendrochronological and radiocarbon analysis.
47	Rūtilē Pukienē	Battles for the Vilnius Castles at the end of the 14 <sup>th</sup> c.: dendrochronological evidence
48	Marzena Kłusek, Michael Grabner, Sławomira Pawełczyk, Jacek Pawlyta	Multi-century long temperature reconstruction based on a multi-proxy dendroclimatological research
49	Maciej Sykut, Sławomira Pawełczyk, Bogumiła Jędrzejewska, Magdalena Niedziałkowska	Differences in stable carbon ( $\delta^{13}\text{C}$ ) and nitrogen ( $\delta^{15}\text{N}$ ) isotope ratios in bone collagen of modern red deer ( <i>Cervus elaphus</i> ) inhabiting various habitats

# **ORAL PRESENTATIONS**

# **Invited Speech**

## Formal stratigraphic subdivision of the Quaternary

Leszek Marks<sup>1</sup>

<sup>1</sup>*Polish Geological Institute - National Research Institut, Warszawa, Poland*

Contact: Marks Leszek, email: leszek.marks@pgi.gov.pl

It is based on the Standard Global Chronostratigraphic Scale, a major goal of which is the establishment of hierarchical chronostratigraphic units of worldwide scope that will serve as a standard scale of reference for dating and for relating all rocks everywhere to world geologic history. Stratigraphic classification requires accurate and precise internationally acceptable terminology and procedures. Chronostratigraphic units encompass all the rocks formed during a specified interval of geologic time whereas geochronologic units represent time intervals and thus they are not stratigraphic units. To make this relation comprehensive, both chronostratigraphic and geochronologic units that represent the same interval of geologic time bear the same name.

The stage is the basic working unit of chronostratigraphy and it is the lowest ranking unit in the chronostratigraphic hierarchy that can be recognized on a global scale. Basic principles used in subdividing the Quaternary into chronostratigraphic units require boundary definitions and designation of boundary-stratotypes. A stratigraphic unit can be formally recognized but then it needs to be defined at a specified locality (stratotype or type section) where it is well exposed and developed, in order that it will be used as a common material standard of reference for identification. A stratotype is the specific stratal sequence used for the definition of the stratigraphic unit or boundary being defined whereas a type area encompasses a stratotype of a stratigraphic unit or boundary. Definition of a chronostratigraphic unit places emphasis in selection of the boundary-stratotype of its lower boundary whereas its upper boundary is defined as the lower boundary of the succeeding unit. Such procedure avoids gaps and overlaps in the Standard Global Chronostratigraphic Scale. Boundaries of chronostratigraphic units are isochronous palaeosurfaces that can be reconstructed using different criteria. In practice, stages are defined by boundary stratotypes, determined as points ('golden spikes') in continuous sequences of strata that constitute framework of the Global Stratotype Sections and Points (GSSP). In turn, stages are grouped in series and these in systems.

The Quaternary System is subdivided into 2 series including Pleistocene and Holocene. The Pleistocene is composed of 4 stages, the lower boundaries of which were defined basically by palaeomagnetic reversals. The stages Gelasian (lower boundary 2.588 Ma BP) and Calabrian (1.806 Ma BP) are formal units determined in marine sequences in southern Italy. Chibanian (771.5 ka BP) is defined in marine deposits in Japan and is under a formalization procedure at present. The youngest stage is tentatively named Tarantian (130 ka BP) after the suggested stratotype in southern Italy but its formalization is still far apart. The Holocene is composed of 3 stages with their lower boundaries defined based on climatic events. They include Greenlandian (11,700 b2k) and Northgrippian (8,236 b2k) with boundary-stratotypes recorded in Greenland ice cores, and boundary-stratotype of Meghalayan (4,250 b2k) was fixed in Indian speleothem. Establishment of stages in the Quaternary laid foundations for the official use of the higher-rank stratigraphic units including Lower, Middle and Upper Pleistocene, and Lower, Middle and Upper Holocene. These terms and their geochronologic equivalents (Early, Middle and Late Pleistocene or Holocene) are exceptionally convenient and thus widely used in Quaternary stratigraphy

## SESSION 1

### **Mortars**

## Sample preparation tests for radiocarbon dating of mortars

Alf Lindroos<sup>1</sup>, Thomas Schröder Daugbjerg<sup>2</sup>, Jesper Olsen<sup>2</sup>, Åsa Ringbom<sup>1</sup>, Jan Heinemeier<sup>2</sup>

<sup>1</sup>*Department of Geology and Mineralogy, Faculty of Science and Engineering, Åbo Akademi University, FI-20500 Turku, Finland*

<sup>2</sup>*Aarhus University, Aarhus, Denmark*

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Radiocarbon dating of lime mortars date the time of construction, when the mortar hardened. In historical sites with mortared stone construction, mortar dating can contribute to solve historical and archeological questions. The sequential dissolution method has successfully dated lime mortar from buildings in Nordic countries, while mortars from Jerash in Jordan proved more difficult to date. The Jerash mortars have a pronounced dead carbon contamination, and produce erroneous high ages. Therefore, there is a challenge to expand the method of mortar dating to mortars with pronounced dead carbon.

Thermal decomposition is an alternative approach to mortar dating, where a furnace heats the sample above 700°C and carbon is released as CO<sub>2</sub>, which can be collected from different temperatures to provide a profile. This contribution presents experimental research in thermal decomposition to suppress dead carbon contamination. This study also develops other methods for dead carbon suppression. Sedimentation is a method where a sedimentation tank sorts crushed mortar in grain size and density fractions. Titration is another alternative method where water suspends a powdered sample, and one injects acid in small batches.

The study tests thermal decomposition for various samples, and compares with sequential dissolution results. The sample Kastel09 from Kastelholm in Finland successfully dates to the 14<sup>th</sup> century, which agrees with previous sequential dissolution mortar dating and written records of Kastelholm Castle. Samples from Jerash in Jordan do not produce successful results with thermal decomposition. The result is similar to previous mortar dating with sequential dissolution. The samples from Jerash belongs to Roman era and Byzantine era. Work on the method of sedimentation and method of titration is progressing and results are expected.

The experiment establishes that thermal decomposition successfully releases CO<sub>2</sub> from mortar samples, which can be radiocarbon dated with accelerator mass spectroscopy. The successful dating of the sample Kastel09 demonstrates that thermal decomposition is a viable method for sample preparation. However, thermal decomposition does not provide an advantage to deal with dead carbon contamination in Jerash samples.



## Sequential dissolution of carbonate rocks in context of mortars dating

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Different techniques of mortar preparation for radiocarbon measurements take into account that the natural carbonates from aggregate and the anthropogenic carbonates from binder dissolve in acid at different rates (Lindroos et al., 2007; Michalska and Czernik, 2015). The leaching reaction of carbonates with concentrated  $\text{H}_3\text{PO}_4$  in a vacuum line is one of the preparation stages involved in  $^{14}\text{C}$  dating with the AMS techniques. The dissolution rates are strongly dependent on mineralogy of the samples. The course of the chemical dissolution of carbonaceous rocks over time show the potential influence of variegated natural carbonates on the different gas portion during sequential dissolution of mortar which is a mixture of natural and anthropogenic carbonates (and other components). We present our experimental data for carbonate rocks and mortars and evaluate the effectiveness of our preparation techniques.

Lindroos A, Heinemeier J, Ringbom Å, Braskén M, Sveinbjörnsdóttir Á. 2007. Mortar dating using AMS  $^{14}\text{C}$  and sequential dissolution: examples from medieval, non-hydraulic lime mortars from the Åland Islands, SW Finland. *Radiocarbon* 49(1):47-67.

Michalska D, Czernik J. 2015. Carbonates in leaching reactions in context of  $^{14}\text{C}$  dating. *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms* 361: 431-439.

## **Radiocarbon dating of the Roman Mérida Amphitheater in W Spain. Challenges with an unusually hard and impermeable mortar.**

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The Roman city Emerita Augusta or present-day Mérida was founded in BC 8 by emperor Augustus and the amphitheater is supposed to be from the same time according to written sources. In the year 2000 we took four samples from the site, from positions that were supposed to represent original mortars. This was at a stage of developing mortar dating procedures and testing them at different archaeological sites. The mortars in Mérida were of extremely hard structure and difficult to sample and it turned out that the ages they yielded were unreasonable, that is, they were too young. At that time we dissolved about 50% of the soluble carbonate from the sample and dated it as two successive CO<sub>2</sub> fraction; the first one after about one minute and the second one after some 10-20 minutes. However, it turned out that the second CO<sub>2</sub> fraction systematically yielded an age closer to the expected age. This encouraged us to do complete dissolution of one of the samples in six successive CO<sub>2</sub> fractions and date them all. Among these, fractions 3, 4 and 5, representing the CO<sub>2</sub> from 38-95% dissolution gave a reasonable age, however not Augustan, but rather Flavian from late 1st c. AD.

In 2018 we made new preparations of the Mérida samples because we now had more experience with mortars having components of young, rapidly dissolving carbonate. This time we concentrated on dating CO<sub>2</sub> fractions from later in the dissolution process. Three of the samples yielded mutually similar late AD 1st c. ages and one of the samples even slightly younger. The results raise the question: Is the amphitheater Augustan or Flavian and/or were our samples original or later additions/repairs.

## **<sup>14</sup>C dating of mortar from ruins of an early Medieval church Hohenrätien GR, Switzerland**

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Interest in direct dating of mortar is growing, as are the chances for cross-checking of the used preparation methods. The fact that mortars, stucco and fresco, i.e., anthropogenic carbonates have different physical and chemical properties is explored in our method. In the process of sieving, we separate fine fraction of carbonates (45-63 µm). This fraction is then trapped for AMS analysis after being dissolved in concentrated phosphoric acid. The first 6 sec (2 x 3-sec dissolution interval) are considered to originate from the anthropogenic carbonates. Two more fractions (each 3 sec) are collected from observing the change in <sup>14</sup>C ages. In most of the cases, the 3<sup>rd</sup> and 4<sup>th</sup> fractions are significantly older indicating the presence of old carbonates (Hajdas et al. 2017). An early Christianity monument church with baptistery located on a hill of Hohenrätien, Canton Graubünden, Switzerland, which was extensively studied by archeologists (Gairhos and Janosa 2011). We will present and discuss the results obtained on samples collected from ruins.

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Hajdas I, Lindroos A, Heinemeier J, Ringbom A, Marzaioli F, Terrasi F, Passariello I, Capano M, Artioli G, Addis A, Secco M, Michalska D, Czernik J, Goslar T, Hayen R, Van Strydonck M, Fontaine L, Boudin M, Maspero F, Panzeri L, Galli A, Urbanova P, and Guibert P. 2017. Preparation and Dating of Mortar Samples-Mortar Dating Inter-Comparison Study (Modis). *Radiocarbon* 59: 1845-1858.

## **Dating earthquake damage of the Modena cathedral vaults (Northern Italy): an integrated approach**

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The medieval Modena cathedral (Northern Italy) was modified in the 15th century with the construction of 23 new vaults, which were progressively added throughout.

A detailed survey of the vaults binder revealed the scars of multiple repair works after several earthquakes, resulting in a complex patchwork of lime mortar repairs over original gypsum vaults and gypsum repairs over original lime vaults. No apparent systematic construction criteria were followed to dictate the use of lime or gypsum binders.

We used an integrated approach based on different absolute dating techniques in order to clarify the original vaults construction timing and to define the chronology of the restorations. The aim was to correlate the main restoration works to the earthquake chronology deduced from the catalogue of historic earthquakes.

Radiocarbon dating using sequential dissolution (Lindroos et al., 2018) and Optically Stimulated Luminescence of the sand aggregate (Panzeri et al., 2018) were carried out to date the lime mortars and Thermo-luminescence to date bricks.

The preliminary results suggest that lime mortar was used both as original building material and for later major repairs. Some vaults were entirely rebuilt using a gypsum binder, and some others originally built using lime mortars were modified at least two times using two different gypsum mortars.

These results are particularly significant because we were able to demonstrate that the vaults suffered much larger damage induced by earthquakes than previously assessed just by mapping fracture and crack networks.

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## SESSION 2

### $^{14}\text{C}$ in Environment

## **To the problem of last large dammed lakes existence in intermountain depressions of the SE Altai, Russia**

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The Russian Altai (mountains of southern Siberia) is one of the regions where extensive ice-dammed lakes were repeatedly formed in intermountain depressions during the Pleistocene. The subsequent warming led to degradation of ice dams and cataclysmic draining of these reservoirs. The estimated magnitude of paleofloods are ranked within the largest known terrestrial discharges of fresh water in the Earth. Significant landscape transformation took place as a result of the geological work of such events not only within intermountain depressions, but also in the drainage valley network over hundreds of kilometers downstream the flood reservoirs.

Today the geomorphological effects and sedimentary records of Pleistocene ice-dammed lakes within the Chuya-Kurai system of basins, as well as such evidences of cataclysmic floods from these reservoirs, are the most studied in Central Asia. Nevertheless, together with the chronology of the Pleistocene Altai glaciations, the chronology of ice-dammed lakes formation and their draining, as well as the character of these flooding events, is highly debatable mainly due to the problems of dating glacial and associated lacustrine and fluvial sediments.

Chuya River valley between the Chuya and Kurai basins is one of the key locations to understand the paleogeography of the high mountainous southeastern part of Russian Altai (SE Altai) – the source area of cataclysmic floods, and to clarify the above-mentioned issues. The Chuya River valley here is a graben that separates Kurai range and Chagan-Uzun massif. Ancient shorelines are expressed along both valley slopes and most clearly indicate former lake levels at about 2100, 1900, and 1800 m a.s.l. This argues the existence of the conjoined Chuya-Kurai lake at some stages of the hydrological system evolution. Particularly in this part of the valley, near the mouth of the Kuektanar River the landslide deposits of giant multievent Sukor paleodislocation together with the terminal moraines of the Kuektanar glacier blocked the Chuya River and impounded the separate lake within the Chuya intermountain depression. Till now ideas about the origin of the dam, the area occupied by paleolake in the Chuya basin as well as the chronology and patterns of its final draining vary significantly. The range of concepts varies from final drying of the Chuya intermountain depression already before MIS-4, to presence of a relatively large dammed lake there till the end of the Holocene, or final draining of last landslide-dammed lake in Chuya valley between Chuya and Kurai basins as a result of dam collapse triggered by the 1761 Great Mongol earthquake.

This paper presents the results of multidisciplinary investigations within the Chuya River valley between the Chuya and Kurai basins, including detailed geomorphological study, litho-stratigraphic and morphological pedogenetic descriptions, geoarchaeological analysis. Geochronological reconstructions were based on radiocarbon and OSL dating of deposits of various genesis. Generally, 10 sections were studied. One OSL date together with the more than twenty  $^{14}\text{C}$  age estimations provide important chronological benchmarks of the late Pleistocene-Holocene hydrological system transformation. New data clarify the issue of the Holocene lake existence in the Chuya basin, as well as chronology and patterns of its final draining.

Study was partly funded by RFBR (grant 18-05-00998).

## **Problems of applying radiocarbon analysis for dating contemporary and fossil soils within tectonically active mountain terranes (by the example of the SE Altai)**

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Altai Mountains (mountains of southern Siberia) are tectonically active northern segment of Central Asia collision belt. During the last Cenozoic orogenesis, accumulation of sediments here began at the Tertiary time. By the beginning of the Pleistocene the altitude of the ridges had been sufficient for developing of powerful glaciations and related impounding of vast ice-dammed lakes in intermontane depressions. Subsequent ice dam failures triggered cataclysmic outburst floods causing significant landscape transformations both in depressions and in the downstream drainage valley network over hundreds of kilometers.

Most ancient and high mountainous southeastern part of Russian Altai (SE Altai), presented in this study, is characterized by complicated tectonic and sedimentation history. As a result of tectonic movements, Tertiary organic bearing lacustrine and boggy deposits had been partly uplifted and exhumed on the ridge's slopes. During the Pleistocene these deposits were affected by various exogenous processes including glaciation, glacio-fluvial activity, erosion from ice-dammed lakes, sliding during lake draining events, followed by further intensive Holocene erosion, pedogenesis and permafrost formation/degradation. There are also locations of even more ancient (Late Paleozoic (Middle and Upper Carboniferous) and Mesozoic (Lower Jurassic)) coal deposits in the region, which are associated with fault boundaries between intermountain depressions and framing ridges. After exhumation these deposits were affected by the same exogenous processes.

Such complicated sedimentation history in the region (which is generally not so rare for tectonically active mountain uplifts) provides a source of ancient organic matter. Being involved into further geomorphic and pedogenesis processes it gives an opportunity to affect the results of radiocarbon dating, which is today the most exploitable and widely applicable technique for making geochronological reconstructions. Presented in our recent publications numerous radiocarbon dates for deposits of different genesis, contemporary and fossil soils within intermountain depressions and mountain valleys of the SE Altai revealed several typical problems in interpretation of some dating results. It was confirmed by multidisciplinary investigations of associated sediments in a wider regional context. One of these problems is obtaining of apparent (more old)  $^{14}\text{C}$ -ages for contemporary and buried soils in situ, for which ancient organic material is involved in pedogenesis.

This paper presents a discussion of obtained apparent radiocarbon dates of fossil soils within the largest (in Altai) Chuya intermountain depression. In addition to radiocarbon analysis in each case multidisciplinary study, including micromorphological, micropaleontological, pollen analyses, was carried out in order to proper interpreting of obtained dates, as well as for explaining inability of direct using of apparent  $^{14}\text{C}$ -ages as a chronological basis for any reconstruction. In some sections radiocarbon dating of charcoal provide additional chronological data. Presented analysis is of vital importance for revealing periods favorable for soil formation; establishing time of last ice-dammed lakes formation and their draining; estimating time intervals of intensified seismicity, which caused deformations or breaks of soil horizons.

The study was partly funded by RFBR (grants 17-04-01526 and 18-05-00998).



## Dating the Nemunas delta progradation - a multiproxy approach

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On the base of archival topographical maps, set of drillings (done both in the Nemunas delta and Curonian Lagoon), results of sedimentological analyses and radiocarbon dating there have been reconstructed the phases of river Nemunas delta development. It has been observed/noticed that for the structure of sediments and rate of sedimentation the most important impact had at the beginning the natural processes regulated by climate changes and relaxation/isostatic process after the degaradation of the Pleistocene ice sheet and later from some 3000-4 000 years BP human economic activity and climate changes, Especially during the last 1500-2000 years the human impact was extremaly visible. Deforastation and introduction of agriculture in new areas resulted in acceleration of erosional processes and increased the suply of the mineral and mineral-organic deposits into the Nemunas river channel and its tributaries and faster progradation of the river delta. It also resulted in the vertical aggradation processes within the proximal part of the delta (vicinity of Sovietsk town) and creation of rhythmically layered deposits in the distal part (Rusne area). A very fast development is noted especially in 19<sup>th</sup> and begining of 20<sup>th</sup> centuries. In oppinion of authors it was due to the deforestation and very intensive agriculture activity (with potatoes and beetroots having the vast share in the structure of land use). Also very important were more often extreme hydro-climatical events within the catchment of the river. The decrease in the delta progradation during the last 50-60 years can be the result of dam construction on Nemunas river in the vicinity of Kaunas (in 1955-1959).

## Effect of dating model on a peat-based reconstruction of Pb deposition history

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The aim of our study was a reconstruction of atmospheric Pb deposition over the Holocene, using an ombrotrophic peat bog. Particular attention was paid to the effect of dating model on the Pb deposition calculation during the past 100 years.

An ombrotrophic bog Staroselsky Mokh is located in the Central Forest State Natural Biosphere Reserve, Tver region, Russia. The potential sources of anthropogenic Pb are leaded gasoline, brown coal mining (1948–1996) and dust resuspension from the coal waste heaps located 40 km away.

Concentrations of a wide range of elements and isotopic composition of Pb were determined in peat and coal samples using QICP-MS NexION 300D, after ashing and complete digestion in HF and HNO<sub>3</sub> mixture. Dating of the lower part of the peat profile (48–550 cm) has been based on  $^{14}\text{C}$  measurements in sphagnum using accelerated mass spectrometry (AMS, Radiocarbon Laboratory, Institute of Physics, Gliwice, Poland). The upper part (0–64 cm) was dated using the  $^{210}\text{Pb}$  and  $^{137}\text{Cs}$  isotopes. The Pb deposition during the past 100 years was calculated using three dating models. Two of them were based on  $^{210}\text{Pb}$ : Linear Regression Model (LRM) (<http://www.flettresearch.ca>) and Constant Rate of  $^{210}\text{Pb}$  Supply model (CRS) (Appleby, 2001). Uncertainties were estimated using the calculus of error propagation. Both LRM and CRS models gave similar age till the depth about 50 cm; the discrepancy increased to the bottom of the profile. At a depth of 64 cm, CRS age was  $105 \pm 54$ , LRM— $94 \pm 8$  yr. Due to the way of error calculations, the uncertainty of CRS dates was much higher than LRM dates, especially in the deep sections where the amount of unsupported  $^{210}\text{Pb}$  remaining in the profile was low. The errors of CRS ( $\pm 1$  STD) were about  $\pm 3$  years at the age of 10 years, and  $\pm 50$  at the age of 100; LRM errors were  $\pm 1$  at 11, and  $\pm 8$  at 94 years.

The third model was a Bayesian Bchron age-depth model (Haslett and Parnell, 2008) constructed using AMS  $^{14}\text{C}$  dates and four  $^{210}\text{Pb}$  dates (LRM). The Bchron model was used to calculate Pb deposition over the whole ombrotrophic part of peat profile covering 5400 years.

Deep layers (200 BC–3400 BC) of the ombrotrophic peat represented the background pre-anthropogenic Pb atmospheric deposition flux and isotopic composition:  $0.017 \pm 0.004$  (SE) Pb mg·m<sup>-2</sup>·yr<sup>-1</sup>, and  $^{206}\text{Pb}/^{207}\text{Pb} = 1.197 \pm 0.006$  (SD),  $^{208}\text{Pb}/^{206}\text{Pb} = 2.080 \pm 0.006$  (SD) respectively. Already 1500–2000 years ago, Pb concentrations started to grow, and isotopic composition started to shift towards the less radiogenic values of ore-Pb. Deposition of Pb reached a maximum in 1930–60s and then started to decrease. According to isotopic ratios, the source of anthropogenic lead in peat in the XX century was Russian leaded gasoline, the influence of coal was not identified.

Calculation of Pb deposition level vs time was sensitive to the dating model. The Bchron and LRM models gave a narrower time interval of highest Pb deposition (Bchron: 1938–1978, LRM: 1936–1974) than the CRS model (1924–1979). According to Bchron, maximum Pb deposition took place in 1960 and exceeded the pre-anthropogenic background about 1600 times. Two other models gave similar maxima and dates—LRM 1250 (in 1954), and CRS—1260 (in 1955) times over the background. The recent deposition (in 2012–2013) is 64 (Bchron), 86 (LRM) and 89 (SRC) times above the pre-anthropogenic average.

The study is supported by the Russian Foundation for Basic Research, project N18-05-01115a.

# SESSION 3

## **Archaeology**

## **Absolute Chronology of Baden: Radiocarbon changes the narrative?**

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In our contribution we address the topic of current state of radiocarbon dating of Baden in the Carpathian Basin from a beyond-site-chronologies perspective. By means of Bayesian modeling with datasets selected from the total of compiled 200 conventional radiocarbon determinations from archaeological contexts of Baden and isochronous cultures we demonstrate the limitations of traditionally viewed development of the culture, which is rooted in typological approach (pottery) and its straightforward projection onto the calendar time-scale. The results based on empirical results are buttressed by simulations in time-periods for which no radiocarbon determinations are available. Our results show that traditional interpretative narratives concerning development and dispersal of Baden artefactual records are, at least in part, in need of change.

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## **Absolute chronology of the Early Eneolithic units in Lesser Poland. A discourse between pure radiocarbon and context-conditioned dating**

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The common vision of the Early Eneolithic period in Lesser Poland assumes the existence of two separate units: the Lublin-Volhynia culture and the Wyciąże-Złotniki group. The former would have covered the eastern and central part of the territory under discussion, from the last quarter of the 5<sup>th</sup> millennium cal. BC to mid-4<sup>th</sup> millennium cal. BC. The latter would have occurred only in a relatively small region in the Kraków area, in the second quarter of the 4<sup>th</sup> millennium BC. In recent years, new data have been obtained, referring to their absolute chronology and territorial distribution. Coupled with the new external information and interpretations, they have changed to a fairly large extent the previous state of knowledge on the issues of chronology and interrelations of these units. Currently, it is possible to suggest that both units operated in parallel, from ca. 4300 cal. BC to nearly 3500 cal. BC and that the sharp distinction between them should be reduced. However, critical analyses of available 14C dates, made from the point of view of the quality of dated samples and their contexts, as well as their Bayesian interpretations, indicate an alternative, much shorter vision of the absolute chronology of these units, ca. 4100-3800 cal. BC. In the presentation an attempt will be made to estimate the probability of both scenarios, in the light of traditional typological indicators (mainly ceramic ones) coming from Lesser Poland and neighboring territories. A critical evaluation of significance of such indicators for reconstructing the relative and absolute chronology of the Early Eneolithic phenomena in the upper Vistula basin will also be presented.

## **Ancient logboats in Lithuania: new finds, wood species and chronology**

Kęstutis Peseckas<sup>1</sup>, Gytis Piličiauskas<sup>2</sup>, Elena Pranckėnaitė<sup>2</sup>, Simona Matuzevičiūtė<sup>3</sup>, Rokas Vengalis<sup>2</sup>, Jonas Mažeika<sup>4</sup>, Žana Skuratovič<sup>4</sup>

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The earliest evidence of use of logboats or dugout boats (vessels made of a single trunk of tree) in Europe comes from Late Mesolithic period, i.e. ca. 7000 cal BC. In Lithuania logboats have been extensively used for fishing, transportation and traveling in rivers and lakes until the middle of 20<sup>th</sup> century even though more advanced and complex boats made of wooden planks were already available. To this day more than 70 logboats are known in Lithuania and around half of them can be considered ancient, i.e. made before 1800 cal AD. In 2015 a logboat was discovered during test-pitting at Šventoji 58 site in coastal Lithuania. This newly discovered dugout was made from oak tree in ca. 2700 cal BC and it was most likely used by Globular Amphora culture community. Today Šventoji 58 logboat is a first nearly complete Stone Age vessel that has been ever found not only in Lithuania but also in the whole Eastern Baltic, i.e. Finland, Estonia, Latvia and Lithuania. During the recent underwater dives some new logboats were also found. They were radiocarbon dated and their wood species were identified. Here we present <sup>14</sup>C dates and other information considering the newly discovered dugouts. Radiocarbon (<sup>14</sup>C) dating of the wood samples was undertaken at 4 laboratories - the Poznań Radiocarbon Laboratory (Poland), the <sup>14</sup>Chrono Centre for Climate, the Environment and Chronology, Queen's University Belfast (UK), the Centre for Physical Sciences and Technology in Vilnius (Lithuania) and the Laboratory of Nuclear Geophysics and Radioecology, Geology and Geography Institute, Nature Research Centre in Vilnius (Lithuania).

## **Stratified sampling of human remains for accurate $^{14}\text{C}$ dating. Chronometric studies on Eneolithic burials discovered in Mikulin 9 (Poland) and Urziceni-Vamă (Romania)**

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The usefulness of  $^{14}\text{C}$  dating is assessed by prehistorians according to two qualities – precision and accuracy of results obtained with regards to past target events.

It is generally agreed that the precision depends mainly on the technological constraints of the method. Thus the resulting measurement is always a product of the examined material and the available techniques currently applicable, be the latter due to general advancement of methodics in the field of radiocarbon dating or limitations of a laboratory performing measurements.

Radiocarbon laboratories regularly advise to their customers about sample selection and inform them about outcomes that can be expected in given starting conditions. It is also common to apprise the customers of possible technical improvement of radiocarbon dates' precision. As it is generally known, laboratory practices can also affect the accuracy of  $^{14}\text{C}$  dating. This is achieved by the preparation of samples to be dated within more and more refined pretreatment protocols that allows the removal of carbon contaminants.

Ultimately, the selection of samples possibly yielding measurements accurate enough to solve chronological problems under scrutiny depends on archeologists. For this reason, they must assess causal (and temporal) relationships between relevant prehistoric event and material to be dated.

Even if the resulting dates correspond with targeted 'moments' in the past, feasibility of results is decided not on the basis of quality of the sole  $^{14}\text{C}$  measurements themselves, but rather on derived calibrated dates. It is commonly known that plateaux on calibration curves can spread even the most precise and accurate radiocarbon date to an unsuitably long single or even several calendar periods. In such situations only the modelling of well predefined sequences of dates (not necessarily just  $^{14}\text{C}$  ones!) with the use of Bayesian statistics can yield conclusive outcomes. Conventionally, such models are founded on the stratigraphic or chrono-typological ordering of different elements of the archaeological record, each with radiocarbon measurements. However, when circumstances are not favourable for obtaining precise and accurate  $^{14}\text{C}$  age determinations directly regarding the targeted prehistoric events, and there is no firm contextual ground for their Bayesian modelling, many archaeologists choose not to undertake radiocarbon dating at all.



In some cases, the “wiggle-matching” of  $^{14}\text{C}$  dates obtained for natural sequences connected with the prehistoric human agency in a definable way offer an excellent alternative. With this study we want to demonstrate that radiocarbon measurements for selected bones from single skeletons can produce such attractive series.

The radiocarbon dating of human skeletal remains from two inhumations discovered at the Eneolithic cemeteries of Mikulin 9 (E Poland) and Urziceni-Vade Ret (NW Romania) were a starting point for our short chronometric study. The sampling strategy and consequent modelling applied here is based on an assumption that each skeleton of a single individual can be considered as a set of stratified carbon reservoirs providing us with an at least elementary sequence of two  $^{14}\text{C}$  measurements corresponding with moment of birth and death of a buried person, and with anthropologically determined gap between them. The examples clearly show that the selection of bone samples in accordance with the suggested criteria may raise accuracy of radiocarbon age-at-death determinations by a dozen or even several dozen percent.

Obviously, this paper discusses not only the apparent advantages but also main disadvantages of the proposed approach. On this occasion we also want to attract some attention to the problem of the optimal selection of radiocarbon samples within a wider agenda of bone-based bioarchaeological research (including all isotopic and genetic analyses) that inevitably become a routine of modern prehistoric studies.

## First steps in dating of Celtic fields in the Czech Republic

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Development of removed sensing methods in landscape archaeology, especially Lidar, caused discovery of features which are similar like what is called Celtic fields in North-West Europe. These fields were identified in White Carpathians and Ždánice forest located in Eastern part of the Czech Republic. So called Celtic fields are square or rectangular structures separated by elevated earth walls. These walls were accumulated due to criss-cross ploughing, when arable land was turned back always in the end of the field. It was argued, that these accumulations could be dated by OSL methods. Sampling of two selected sites, Čertoryje in White Carpathians and Kobeřice in Ždánický forest was performed. Čertoryje national nature reservation protect unique rich meadow vegetation, site was never affected by modern ploughing. The site is closely connected with Bronze Age hillfort, in centre of reservation is recorded Early Medieval settlement and deserted High medieval village. LIDAR evidence shows Celtic fields dated back to 10<sup>th</sup> century AD by OSL. This is supported by superposition with High Medieval strip field system and unclear superposition with landslides dated back to Early Bronze Age. Čertoryje moreover provided several C14 dates of soil charcoals with timespan since Bronze Age to Early Mediaeval. It could be preliminary concluded that these fields had longer continuity and its active use was proved at least for Early Middle Age. OSL dating of Kobeřice site is in progress. Identified features and landscape context of both sites is similar in aspects as: presence of Bronze Age hillfort nearby and superposition with High Medieval field system. Main difference is recent presence of wood instead meadow in case of Kobeřice. Moreover, there were found charcoals and prehistoric potshards during sampling in Kobeřice. Identification of so called Celtic fields and dating of these structures provided new insight into landscape evolution in the western edge of Carpathians.

# Lecture

## **Optically stimulated luminescence dating using quartz**

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Optically stimulated luminescence (OSL) was first observed from natural quartz over 30 years ago. The signal found application to dating a number of different types of samples either bleached by sunlight or fired. New methods applying this signal are being continuously developed and improved.

The lecture will present the basic principles of the method along an overview of the signals that are currently being used. Some attention will be devoted to the interpretation of the obtained results.

## SESSION 4

### **OSL-methods**

## **SAR protocol using thermally modulated OSL (TM-OSL) of quartz**

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Inducing changes in the optical cross-section (OCS) by heating a sample during optical stimulation can be used to control the OSL process in order to improve the separation of OSL signals originating from different traps [1]. Such a method, called thermally modulated OSL (TM-OSL), can be realized technically in a simple way by applying readers conventionally used in OSL dating supported by additional LED stimulation source. It has been shown recently that the fast OSL component in quartz can be separated from other OSL components on the stage of experiment when the optical stimulation is conducted with the wavelength 620 nm during the linear heating of a sample to 200 °C [2]. Such a TM-OSL measurement is an easy test for the presence of the fast component in the OSL signal of a quartz sample.

The OSL signal of quartz is complex. Three to six components can be observed depending on the sample [3]. The component that decays fastest is the most appropriate for age assessment because of the condition of OSL signal zeroing before the sediment layer creation. In the OSL dating protocols using quartz, it is assumed that the very first part of the OSL curve corresponds mainly to the fastest OSL component and therefore this part of OSL signal is used for equivalent dose calculation. However, it is hard to verify by standard measurements during the dating procedure that fast component really dominates the total OSL signal. Likewise, application of the analytical techniques of the OSL curve decomposition into individual components before the age determination is unrealistic in dating practice. As it was shown that the TM-OSL method allows the selective detection of the OSL components, it is reasonable to test the usefulness of this kind of optical stimulation in SAR protocol.

Here, consequences are presented of substituting the CW-OSL measurement applied up to now in the SAR protocol by the TM-OSL measurement. The optical stimulation is carried out with the LED stimulation module delivering light with the wavelength of 620 nm and the power of about 50 mWcm<sup>-2</sup> at the sample position. The outcomes of the investigation to determine the most suitable preheat temperature and OSL signal bleaching conditions are presented as well as results of the recycling, recuperation, and recovery tests. Quartz samples used in experiments originate from sediments of different origins and have different characteristics of OSL signal. Results of equivalent dose determination by the SAR TM-OSL protocol are compared with results obtained by conventional SAR protocol.

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## Environmental radioactivity and dose rate measurement with the $\mu$ Dose system

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$\mu$ Dose is a novel system for assessing environmental radioactivity and the radiation dose rate in sediment and ceramic samples.  $^{238}\text{U}$ ,  $^{235}\text{U}$ ,  $^{232}\text{Th}$  decay chains and  $^{40}\text{K}$  specific radioactivities are assessed by  $\alpha$  and  $\beta$  radiation detection along with four decay pair  $^{214}\text{Bi}/^{214}\text{Po}$ ,  $^{220}\text{Rn}/^{216}\text{Po}$ ,  $^{212}\text{Bi}/^{212}\text{Po}$  and  $^{219}\text{Rn}/^{215}\text{Po}$  decay pairs. This assessment provides results with correlated uncertainties that require the development of an error estimation methodology.

In this work we present a dose rate calculation module based on Monte Carlo and Bayesian methods that is built into the  $\mu$ Dose system. This module allows to take into correlated uncertainties which arise in combined  $\alpha$  and  $\beta$  and decay pairs counting. We demonstrate the advantage of including the uncertainty correlation in radiation dose rate calculation. In this work we show the improvement in dose rate precision for a number environmental samples taken for trapped charge dating.

The  $\mu$ Dose system offers  $^{238}\text{U}$ ,  $^{235}\text{U}$ ,  $^{232}\text{Th}$  decay chains and  $^{40}\text{K}$  specific radioactivities determination in a single measurement. Build into the system dose rate module offers increased dose rate precision in trapped charge dating with a probabilistic Monte Carlo and Bayesian approaches to data analysis. This gives significant improvement in precision when small samples are being measured.

KT, GP and PM acknowledge the support by the Polish National Science Centre, contract number 2018/30/E/ST10/00616 which allowed dose rate measurements.

## Problems with precise determination of dose rate in luminescence dating with $\gamma$ spectrometry due to the $^{222}\text{Rn}$ leakage

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Trapped charge dating is widely used for assessing age of geological sediments and archeological artifacts. This is done by measuring the total absorbed radiation dose and the radiation dose rate. The age than calculated from

$$\text{age} = (\text{total absorbed radiation dose}) / (\text{radiation dose rate}).$$

Therefore, age precision and accuracy depends on the precision and accuracy of the total absorbed radiation dose and the radiation dose rate. Where both values needs to be precise and accurate for precise and accurate age. In trapped charge dating radiation dose rate is often determined by the high resolution gamma spectrometry.

In this work we show and investigate radiation dose rate bias in  $\gamma$  spectrometry where uranium decay chain members are determined via  $^{222}\text{Rn}$  daughter isotopes. In  $\gamma$  spectrometry noble gas  $^{222}\text{Rn}$  is emanating from the sample and then leaking from the measurement beaker. Hence some uranium remains underestimated as it is assessed from  $^{222}\text{Rn}$  daughter radionuclides. We investigate this phenomena by injecting  $^{222}\text{Rn}$  rich air into the beakers as well as we measure natural sediments samples which also emanate  $^{222}\text{Rn}$ . Five different beakers commonly used in  $\gamma$  spectrometry technique were tested. Almost every tested beaker exhibited heavy  $^{222}\text{Rn}$  leakage and additional beaker sealing only slightly reduced  $^{222}\text{Rn}$  escape. This leakage leads to the underestimation of  $^{238}\text{U}$  decay chain members when they are measured via  $^{222}\text{Rn}$  daughter products.

To solve this problem we designed and tested a novel construction-  $\gamma$ Beaker. First radon leakage test with  $^{222}\text{Rn}$  spiked air and with natural sediments samples give a promising results for improving the age accuracy in trapped charge dating.

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## **Quartz luminescence sensitivity of fluvial and aeolian samples in the Pannonian Basin**

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The lowlands of the Pannonian Basin are mostly formed of alluvial fans, which have been built by rivers with catchments of different petrographical background. Consequently, the composition and mineralogy of sediments is also different. The dynamics of fluvial activity, the development of forms and thus sedimentation characteristics, such as transportation distance or the number of sedimentary cycles, are also changing from site to site. Moreover, several alluvial fans were left behind by the rivers due to tectonic forces, and consequently the sediments were reworked by aeolian processes during the dry phases of the Late Pleistocene and the Holocene.

All these factors mentioned above can have a significant effect on the luminescence behaviour of mineral grains used for Optically Stimulated Luminescence (OSL) dating. It has been clearly shown by earlier research that in terms of the most frequently used mineral, i.e. quartz, both mineralogical differences and repetition of sunlight exposure can influence the so called luminescence sensitivity, i.e. the luminescence intensity given in response to a unit radioactive dose. This feature can be examined and quantified during the dating procedure and has a not yet fully explored potential in reconstructing sediment history and geomorphological development.

The aim of the present study therefore is to analyse and compare the luminescence sensitivity of coarse-grained quartz samples from several sites along the Danube, Tisza, and Maros Rivers and their alluvial fans. Detailed measurements were made on 20 fluvial samples of identical grain size (90-150 µm) using both TL and OSL, applying continuous wavelength CW-OSL, linear modulated LM-OSL techniques concerning the later. The sensitivity of an additional 40 aeolian samples were also determined using CW-OSL measurements. Weight normalised total intensity (base sensitivity value) and sensitivity change through 9 cycles were compared to explore the differences.

Results show that in case of all fluvial samples the TL 110 °C peak, CW-OSL results and fast component intensity correlate well. The total base sensitivity of Danube quartz can be well distinguished from that of Tisza and Maros Rivers, as their sensitivity values are about half as much as the values of the other two areas, Danube quartz has the smallest fast component ratio. Meanwhile, Tisza and Maros quartz values do not show a noticeable dissimilarity. Sensitivity values related to Aeolian sediments do not show a remarkable spatial pattern, i.e. values showed a high fluctuation within and between alluvial fans, referring to the importance of other parameters than mineralogical composition. However a remarkable correlation was found between burial age and base sensitivity values.

## SESSION 5

### **OSL-applications**

## Revision of the Late Pleistocene loess-palaeosol stratigraphy in Poland

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There are many stratigraphic schemes of the Late Pleistocene loess-palaeosol sequences (LPS) applied in Europe. Probably the first attempts of scientific description of loess in Poland were undertaken by Nałkowski and Siemiradzki at the end of 19th century. They both considered loess as interglacial deposits.

The basics of modern loess stratigraphy in Poland were elaborated about 40 years ago by Jersak and Maruszczak. The Jersak's scheme was developed in the 1960's. The Late Pleistocene LPS is divided into four units: two palaeosols and two loess units: pedocomplex Nietulisko I and two calcareous loess units (younger loess IIa and IIb) separated by fossil tundra-gley soil complex of Komorniki type. In the top of younger loess IIb unit recent soil has developed.

Maruszczak's scheme is more complicated. Above the Eemian – Early Weichselian pedocomplex Gi+GJ1 four loess units are distinguished: lowest younger loess (LMn), lower younger loess (LMd), middle younger loess (LMs) and upper younger loess (LMg). These loess units are separated by three interstadial soils: Gi/LMn, Gi/LMd and Gi/LMs.

The stratigraphic correlation of particular litho-pedostratigraphic units defined by Jersak and Maruszczak is not obvious. It is also complicated by fact, that Maruszczak subsequently changed his primary interpretation and characteristics of some lithostratigraphic units. First loess stratigraphy scheme and chronostratigraphic interpretation made by Maruszczak in the 1970-es was similar to Ukrainian scheme elaborated by Veklich. Pedostratigraphical units in loess record were correlated with successive biostratigraphical units known in Europe in the 1960's.

At the end of the 20th century most of the questions concerning of Late Pleistocene loess in Poland (stratigraphy, age by means of the TL method, rate of deposition, periglacial record and others) seemed to be well explained and documented. Maruszczak claimed that the Late Pleistocene loess sedimentation process in Poland was almost continuous and very well correlated with the marine record.

To verify previous chronostratigraphic scheme of the Late Pleistocene LPS in Poland new research was performed during the last 10 years, using a new methodological approach. Several representative successions were chosen along the latitudinal transect in Poland. These LPS were sampled in vertical continuous sections at close intervals (5 cm) and comprehensively documented. High resolution optically stimulated luminescence (OSL) dating was performed: Post-IR IRSL method for the polimineral fraction (4-11 µm) and OSL method for medium quartz fraction (45-63 µm). Radiocarbon dating has been also conducted for chronostratigraphic modelling.

The research results indicate that Late Pleistocene loess sedimentation in Poland was not a continuous process. Aeolian dust was deposited mainly during MIS 4 and 2. No evidence was found to confirm the significant deposition of loess in the middle pleniveichselian (MIS 3). In warmer Late Pleistocene stages (MIS 5 and 3) the rate of loess deposition was reduced almost to zero. The results of high resolution dating indicate short but very intensive processes of aeolian dust deposition which took place in very harsh climatic conditions with very sparse plant cover.

The research was performed under the National Science Centre project No. 2011/01/D/ST10/06049.

## **The variations in chemical composition of the L1LL1 loess unit in context of age-depth model and spatial distribution – case of Biały Kościół and Tyszowce sections (Poland)**

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The presentation focuses on chemical composition of L1LL1 loess units from two distant Late Pleistocene loess-palaeosol sequences, located approximately on the west-east line, at significant distances from each other (c.a. 500 km). The Tyszowce loess section ( $\lambda=23^{\circ}42'45''\text{E}$ ,  $\varphi=50^{\circ}36'30''\text{N}$ ) is located in the northern part of the Sokal Plateau-Ridge (SE Poland), which is the westernmost part of the Volhynia Upland. The profile in Biały Kościół ( $\lambda=17^{\circ}01'29.6''\text{E}$ ,  $\varphi=50^{\circ}43'38.7''\text{N}$ ) is located in the western part of the Niemcza-Strzelin Hills (SW Poland). Both of the sequences consist of five main units developed in the Late Pleistocene and Holocene: two polygenetic palaeosol complexes (S1 and L1SS1), two calcareous loess units (L1LL1 and L1LL2) and recent S0 soil. The L1LL1 loess unit represents the most "fresh" material, relatively unchanged by the postdepositional weathering and pedogenesis. For this reason the L1LL1 loess best suited for the examination of provenance of the source material and their transportation-related modifications.

The age boundaries for the unit L1LL1 are very similar for investigated profiles, but the thickness of this unit depends from the longitude. The sedimentation rate for the L1LL1 unit in Biały Kościół is about 3 time lower than in Tyszowce. It means that during the creation of L1LL1 unit in the eastern part of Poland existed very good conditions for loess accumulation, significantly better than in the western part.

The analysis of the major, trace and rare earth elements by ICP-MS and ICP-ES methods (Bureau Veritas, Vancouver, Canada) for the  $<63\ \mu\text{m}$  granulometric fractions had been performed under the National Science Centre project no. 2017/27/N/ST10/01208 for Jacek Skurzyński.

UCC normalized spider diagrams for trace elements composition, Chondrite and PAAS normalized REE patterns and patterns of characteristic tracer elements or elements ratios, suggest similar composition of source rocks between investigated L1LL1 loess. In La–Th–Sc diagram, data of investigated sediments fall in a region of mixed source rocks, but near to the border of the field of typical granitic sources.

The loess L1LL1 of Biały Kościół is more weathered (eg. A-CN-K ternary diagram) and more abundant in clayey, aluminous material (eg.  $\text{Fe}_2\text{O}_3/\text{TiO}_2$  vs  $\text{Al}_2\text{O}_3/\text{TiO}_2$  diagram or  $\text{K}_2\text{O}/\text{Al}_2\text{O}_3$  vs  $\text{TiO}_2/\text{Al}_2\text{O}_3$  diagram) compared to the L1LL1 loess of Tyszowce, which is enriched of coarser, more feldsparic material. It may be evidence for mineral sorting from east to the west. Sedimentary sorting lead also to a decrease in the  $\text{SiO}_2/\text{Al}_2\text{O}_3$  with increasing transport distances away from the source area - the value of that ratio in Tyszowce is 17,9 and 14,2 in Biały Kościół. On the other hand the diagrams Th/Sc vs Zr/Sc or Zr/Nb vs Hf/Nb suggest depletion in zircons from the east to the west, when typically the sediment recycling results in enrichment of this mineral. However the very strong positive correlation between Zr/Nb and Hf/Nb suggest similar compositions for the zircons in the deposits between the two regions.

This presentation reports the first detailed multi-elements geochemical study to understand the chemical weathering and provenance of L1LL1 loess in Poland, deposited c.a. in the same time.

## **OSL dating of terrace and floodplain development along the Hungarian Lower Danube**

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The investigation of floodplain and terrace development along the Danube has always been in the forefront of Hungarian geomorphological research. The timing of incision and terrace development phases was mostly determined through geomorphological analysis and comparative sedimentological or climatic studies. Recently, there has been a considerable advance in the application of numerical dating methods for the reconstruction of terrace development, but restricted mostly to older terraces on the Mountainous section of the river.

In the meantime hardly any dates are available for the Hungarian Lower Danube, where floodplain surfaces are just slightly distinguishable, but provide a key to the investigation of the westward shift of the river during the Late Pleistocene and the Holocene. Consequently, the aim of this study is to locate and identify the different floodplain levels, to provide the first numerical ages of palaeo-channels located on these surfaces and to explore the dynamics of fluvial development.

For the analysis OSL was applied and in total 30 samples were dated from different morphological units: channel sediments, point bars, back swamp areas. Considering the possibility of incomplete bleaching and the expected age range the coarse grain quartz fraction was subjected to the measurements. The OSL properties of the samples however were not ideal, primarily because the luminescence sensitivity of quartz was extremely low in some cases, which affected badly the reproducibility and precision of measurements. Finally, by increasing the number of aliquots and applying low temperature treatment an adequate number of data could be collected.

Based on the results the development of 1 distinctive terrace level, and 3 chronologically and morphologically distinguishable floodplain surfaces could be reconstructed. As a matter of the longitudinal divergence of floodplains the major role of tectonic subsidence downstream of the site and concomitant headward incision is clear. For the formation of the terrace (94-95 m asl) only a minimum age could be identified, as the fluvial sediments on this level could be substantially reworked by postformational aeolian processes, therefore we suggest that incision started between 23 and 17 ka. The formation of the oldest stripe (91-92 m asl) on the 20-30 km wide floodplain developing after this event was dated to 9-10 ka. Subsequently the river started accumulation and formed a convex floodplain between 9 and 6 ka, by which a higher floodplain surface (92-93 m asl) developed. Finally, by 3 ka another incision phase took place and the youngest part of the floodplain (91-92 m) evolved. Results suggest that the intensity of subsidence, governing both the westward shift and the development of floodplain levels was changing considerably through time.

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## **Developing a temporal framework for past natural resource exploitation in the Sonian Forest using optically stimulated luminescence dating**

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The Sonian Forest (Central Belgium) has recently been added to UNESCO's List of World Heritage as an example of the extraordinary evolution of the beech ecosystem since the last Ice Age. Interestingly, and while often considered as "untouched" natural heritage, the Sonian forest in fact preserves an undisturbed and extremely vast archive of its (pre)historical exploitation by man, and intensive iron and charcoal production in particular.

So far, the chronology of these features has been entirely based on <sup>14</sup>C-dating of charcoal from above-ground kilns. Most of these ages indicate post-1650 CE charcoal production, a period over which <sup>14</sup>C is of little use. This implies a major gap in our understanding of the chronological order of events and activities during the past couple of centuries.

This study reports on an Optically Stimulated Luminescence (OSL) dating methodology that aims at establishing chronologies for post-1650 CE features with a high temporal resolution. The investigations use sand-sized quartz extracted from sediments that were heated as a result of charcoal production and iron extraction, in combination with the single-aliquot regenerative-dose (SAR protocol). We first document the luminescence characteristics in terms of signal intensity, dose response, a variety of procedural tests (such as recuperation, recycling, dose recovery and dependence on thermal pre-treatments) and completeness of resetting. We address potential problems associated with the (near)surficial position of the investigated features in terms of post-depositional processes and calculation of the dose rate. As a test of accuracy, the obtained quartz SAR OSL ages are compared with <sup>14</sup>C-dates for multiple pre-1650 CE charcoal kilns and roasting places. Finally, the approach is applied to a few younger features as an illustration of its potential. We discuss the time-resolution that can be achieved, with a focus on the temporal resolution that can be achieved to distinguish between generations of charcoal and iron production sites, rather than assigning numerical ages to them.

We conclude that OSL signals from heated sedimentary quartz hold considerable potential for dating the remains of past natural resource exploitation in the Sonian Forest, which is of particular relevance for features that are not older than a few hundred years. In addition, our study provides a firm methodological framework for addressing the chronometric issues pertaining to the vast number of similar structures that are archived within the loamy forest soils of Northwest and Central Europe.

## **Stratigraphic aspects of inland dune formation on Niemodlin Plateau (SW Poland)**

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Rapid and deep palaeoenvironmental changes in the Late Glacial and the Early Holocene have been the subject of numerous studies in the field of chronology and in the reconstruction of these transformations. The European Sand Belt in Central Europe is a remarkably interesting remnant of the Late Glacial aeolian accumulation (Zeeberg, 1988). Due to its geographical location, Poland is characterized by very extensive dune areas, which occur both in the form of large dune fields and individual dunes scattered throughout the country. Niemodlin Plateau (SW Poland) is located in the most southern part of this sand belt. Common inland dune types are formed of windblown sands of river or spillway terraces or of deluvial deposits.

Despite the fact that these sediments are considered to be very good for luminescence dating methods, often is not possible to obtain suitable stratigraphy for investigated places. Therefore, it is advisable to collect also material for radiocarbon dating if it is possible. On Niemodlin Plateau in the investigated places soil-formation processes have been developed at the top of aeolian deposits. The palaeosols from the Bølling and Allerød periods are characteristic time markers which may help to verify absolute time ages obtained by OSL methods from aeolian units. The time of soil formation is well established and correlated with global climate change at end of the Last Glaciation (Kasse, 2002; Kaiser et al., 2009).

The aim of the recent research was to delimit different types of aeolian deposits on Niemodlin Plateau and to examine the lithological properties and age of these deposits. We would like to compare new data from Lower Silesia with former results which indicate Late Glacial and Holocene phases of aeolian dunes activity in Poland (Nowaczyk, 2002).

Three excavations have been prepared in the vicinity of the villages Siedliska and Przechód. Samples have been taken to analyse grain size and other lithological properties. OSL (11 samples) dating have been performed and 3 samples of charcoals (radiocarbon dating) have been gathered for further measurements.

There are 2-3 phases of aeolian sedimentation after the Last Glacial Maximum in this area separated by relatively stable periods of soil formation. In the lower part of the majority of sequences coversands have been noted which start an aeolian sedimentation. In the top of coversands unit and/or initial dunes well developed podsol has been noted. The results of these investigations will start further discussion concerning evolution of the aeolian sedimentary environments in the Niemodlin Plateau soon after the Last Glacial Maximum.

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## Lecture

## **Everything you always wanted to know about radiocarbon\* (\*but were afraid to ask**

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**Abstract.** The radiocarbon dating method based on using the radioactive carbon isotope of mass 14 ( $^{14}\text{C}$ ) to determine the age of objects containing carbon, was developed by Willard F. Libby, in the late 40's of the last century (Libby, 1955), who the first produced radiocarbon date. It quickly found a wide application in archaeology and geology to the dating of organic objects of unknown age. Soon it became clear, that the first assumption made by Libby, of a constant radiocarbon concentration in the past, was wrong.

There are natural and anthropogenic phenomena which may change either the production rate of this isotope in the atmosphere, or due to which its concentration in each reservoir changes over time. It means that to obtain correct age of the sample is necessary to apply the "calibration curve", which linked radiocarbon age with calendar age. Laboratories around the world began to search for material to create such a curve.

The first calibration curve was based on the results of the radiocarbon dating of annual tree rings, whose ages were independently obtained through dendrochronological measurements. The data to construct such a curve are based on material from annual tree rings of pine tree or oak. However, this kind of material is limited in time, mainly because of the extent of occurrence of those species associated with climate change that occur periodically on the Earth (glacial and interglacial periods). At the same time, the low activity of radiocarbon in contemporary biosphere (226 Bq/kgC) leads to difficulties in use of conventional techniques of measurement.

To obtain a reliable result using gas proportional counters (GPC) or liquid scintillation counters (LSC), a mass of a few grams of pure carbon is needed. This barrier was overcome by developing technique which allows direct measurement of the radiocarbon concentration in sample using Accelerator Mass Spectrometer (AMS). This technique permits a precise measurement of the radiocarbon concentration in samples containing a few milligrams of carbon, which can be applied to extend the calibration curve using unique materials like lake and oceanic sediments, corals and macrofossils (i.e. Stuiver, Pearson, 1986, Mook, 1986, Bard et al. 1990, Fairbanks et al. 2005).

## SESSION 6

### $^{14}\text{C}$ methods / Speleothems

### Invited Speech

#### **Radiocarbon dating of iron artefacts**

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The properties of the metal iron and in particular the possibility to dissolve carbon within its crystal lattice, thereby enhancing its mechanical strength, allows in principle a radiocarbon dating, provided that the carbon source is contemporary with the time of metal production. In this lecture, the prerequisites and pitfalls for iron  $^{14}\text{C}$ -dating are discussed with archaeological examples.

A simple carbon extraction can be done by combustion of iron at about 1000°C for several hours, either using the established closed-tube combustion with cupric oxide as an oxygen donator or directly with  $\text{O}_2$ .

Radiocarbon measurements on known archaeological iron samples and modern iron standards with a known  $^{14}\text{C}$  concentration demonstrate significant effects of sampling and cutting, which can be minimized using larger iron pieces and cleaning of cutting edges with corundum grinding tools.

$^{14}\text{C}$ -ages of known-age iron objects indicate age-offsets of a few decades, which includes an old-wood effect and possible contamination during sampling prior radiocarbon measurements. However, larger age-offsets up to 200 years have also been observed and may be linked to recycling of older iron and/or possible effects related to possible carbon isotope fractionation, originating during iron production.

## **Some problems of isotopic fractionation correction in radiocarbon dating and other $^{14}\text{C}$ applications**

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Radiocarbon dating and applications of radiocarbon measurements require taking into account isotopic fractionation correction. The correction should cover changes of  $^{14}\text{C}$  concentration during carbon transfer from atmospheric  $\text{CO}_2$  to the medium where  $^{14}\text{C}/^{12}\text{C}$  ratio is determined. The medium may be graphite or  $\text{CO}_2$  in AMS method,  $\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{C}_6\text{H}_6$  in case of radiometric methods. Almost all the steps in the process of transfer of carbon atoms from atmospheric  $\text{CO}_2$  to “counting medium” introduce isotopic fractionation. The fractionation correction is obligatory in European and American norms (i.e. ASTM D6866-16, EN 16640:2017, EN 16785-1:2016-01) which allow use of radiocarbon method for determination of bio-component share in commercial products. The fractionation correction for  $^{14}\text{C}$  is based on  $\delta^{13}\text{C}$  measurements in a counting medium and assumption of constant differences in  $^{14}\text{C}/^{12}\text{C}$  and  $^{13}\text{C}/^{12}\text{C}$  fractionation. It has been shown by several authors that the latter is not well known. In this presentation I will demonstrate that even when assuming known and constant differences in  $^{14}\text{C}/^{12}\text{C}$  and  $^{13}\text{C}/^{12}\text{C}$  fractionation the correction method described by Stuiver and Polach (1977) may, in some cases, lead to systematic errors bigger than statistical uncertainty of modern determinations of  $^{14}\text{C}$  concentration/radioactivity. It is especially true for mixtures containing dead-carbon substrate what is a case when bio-component share in a product has to be determined. The solution for the problem will be proposed.

### **Acknowledgements**

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## Estimation of age duration for deposition breaks (hiatuses)

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The cave speleothems are important source of paleoenvironmental data. They can be dated by U-series method. The crystallization of cave speleothems is connected with environmental conditions. Geochemical proxies of speleothems calcite depend from environmental conditions like local temperature and amount of rain precipitation. The speleothem crystallization rate depends from amount of seepage water and its chemistry. In specific situation like, acidic chemistry of seepage water or break in seepage of water, the crystallization of speleothem stops, and layers of earlier crystalized calcite can be even eroded. As a result, the deposition break (hiatus) is recorded in speleothem profile. The estimation of the age duration of sedimentation break may be an important problem. One from possible attempt is direct dating by U-series method of calcite layers below and above the hiatus and the estimation of two independent age depth models. For older profiles the oxygen isotopic stratigraphy (OIS) connected with independent chronological benchmark like paleomagnetic benchmarks can be used.

Here we present three different examples of the estimation of hiatus age duration. First example is the stalagmite of Late Vistulian an Holocene age from Pekelny Dom Chamber located in Demanova Cave System (Slovakia). This speleothem is divided by one hiatus. Parts of stalagmite below and above the hiatus have independent U-series age-depth models.

Second example is the ca. 200 - 300 ka old stalagmite from Szczelina Chochołowska cave located in Tatra Mountains (Poland). This stalagmite is divided by three hiatuses. The part of stalagmite below the first hiatus and above the second hiatus have the age-depth models based on U-series ages. The short calcite layer between two hiatuses has been dated only by one U-series date. The OIS approach has been used here to estimate the possible age-depth model for this layer.

Third example is the flowstone profile from Snezna Jama Cave (Slovenia). This flowstone profile is divided by many hiatuses. The paleomagnetic benchmarks places this profile in the time interval between 2 and 5 Ma. The chronology for this profile has been estimated basing on OIS approach and paleomagnetic benchmarks.

## **Paleoclimate reconstruction for MIS 9 - MIS 7 period basing on speleothems records from selected caves in Tatra Mts. (Poland)**

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Speleothems are the useful tools for the paleoenvironmental reconstructions. Their formation is controlled by the several factors e.g. average rainfall, the mean annual temperature and vegetation changes near the cave. Moreover, speleothems are one of the main paleoclimate data sources from terrestrial environment, that usually cover long-lasting, continuous periods of time. Their next advantage is the possibility of its precise dating by U-series methods.

In the presented research, speleothems from the Tatra Mountains region was collected and studied in detail. In the karst rocks of Tatra Mts. (mainly wierchowa limestone series) the longest and the deepest caves in Poland were formed. To date, over 857 caves have been discovered in that region with a total length of over 133 km. The collected speleothems came from the Chochółowska and Kalacka caves, which are located in two of main valleys – Chochółowska and Bystra.

The stalagmite found in the New Corridor of Chochółowska cave is about 21 cm high and has about 10 cm diameter. From Kalacka cave a naturally fractured flowstone with a recorded deformation process was collected.

The U-series dating and age-depth modeling allowed to determine the time of growth both speleothems between 320 and 230 ka, during the MIS 9 - MIS 7 (Marine Isotope Stage). Growth breaks recorded in Chochółowska cave stalagmite are coincident with period of intensive landslides recorded in Kalacka cave speleothem. Multiproxy record of environment changes, preserved in studied speleothems, allows to suggest a possible factors causing speleothems growth breaks and activation of landslides.

The complementary use of several different methods: oxygen and carbon stable isotopes analysis, microfacial analysis and analysis of trace elements content give better opportunity to reconstruct the evolution of past environment conditions. Those multiproxy results are valuable source of information about temperature, precipitation, changes in vegetation intensity and soil activity prevailing in the analyzed time span.

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## **Last Glacial/Holocene transition recorded in the speleothem from the Demianova cave system (Slovakia)**

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Since last 5 million years Earth climate has been dominated by characteristic for ice age cyclicity of climate change, long cold periods (glacials) were cyclically interrupted by short warm periods, known as interglacials. The climate cyclicity was reconstructed basing on archives like ice cores, marine and lake cores. The main difficultness is reliable dating; those archives may not meet the specific requirements of radiometric dating techniques, also it may be difficult to find benchmarks with precise age, like tephra layers or magnetic excursions. Therefore, many Quaternary chronologies bases on indirect approaches, such as record alignment strategies. The Speleothems are valuable archives because of their capability to be dated by the U-series method. However, interpretation of geochemical proxies from speleothems may not always be easy.

Here we present the speleothem from "Pekelny Dom" chamber located in Demanova Cave system (Slovakia). The speleothem contains two generation of calcite crystallization divided by the sand layer. First generation of calcite records the ca. 12 ka long period of last glacial period from 47 to 35 ka. After 35 ka the calcite crystallization stopped and whole chamber has been filled in with sand sediments, which is recorded as a sand layer in presented speleothem. This sand layer is connected with Last Glacial Maximum. The Calcite crystallization start again during the Late Glacial/ Holocene transition. The second generation of calcite crystallized during the Holocene period mostly.



# SESSION 7

## **Tree-rings / Varia**

## **Inter-validation of dendrochronology and $^{14}\text{C}$ dating on a tree-ring sequence of 700 years originating from Eastern Carpathians**

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We present a comparative study performed on a 700-year sequence of dendrochronology ordered tree-rings of *Pinus cembra* originating from Eastern Carpathians for the period AD 1009 to 1709. This period covers the solar minima of the Little Ice Age. The aim of this study was to assess the accuracy of our  $^{14}\text{C}$  determinations interpreted on the IntCal13 calibration data and to observe any apparent offsets. The  $^{14}\text{C}$  measurements on single and double tree-rings were 'wiggles matched' to secure the dendrochronology cross-matching of all the *Pinus cembra* wood pieces. The results showed a very good agreement between the age datasets for 4 out of 5 wood trunks. However, for one of them a new cross-matching was performed after a quality assurance test, establishing an earlier 48 years position, recommended by the 'wiggle matching' Bayesian statistics and dendrochronology analysis. Following this adjustment, the quantification of the  $^{14}\text{C}$  level variability with respect to the IntCal13 calibration curve was obtained by calculating  $\Delta^{14}\text{C}$  for all tree-ring samples. As a final conclusion an insignificant  $^{14}\text{C}$  concentration offset of  $-0.63 \pm 3.76\text{‰}$  was found for the Romanian samples.

## Air pollution by sulfur dioxide on the basis of carbon isotopes in tree rings – case study for Sudeten, Tatra and Suwałki region in Poland

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Trees are interactive monitor of environment and therefore anthropogenic impact has implications for plants physiology and physical response. Since the beginning of industrial revolution, the  $\delta^{13}\text{C}$  of the atmospheric  $\text{CO}_2$  has decreased due to emission of  $^{13}\text{C}$ -depleted  $\text{CO}_2$  from human activities such as fossil fuels burning and land clearing. The so called Suess effect is reflected in tree rings  $\delta^{13}\text{C}$ . Freyer [1], who compared the values of  $\delta^{13}\text{C}$  in annual rings of trees from the control area with less pollution, and from the more polluted area, suggested that the  $\delta^{13}\text{C}$  values in rings are affected not only by the  $\delta^{13}\text{C}$  value of atmospheric  $\text{CO}_2$ , but also other pollutants present in the atmosphere (especially  $\text{SO}_2$ ) that modify the differentiation of the isotopic composition by changing the ratio of intercellular (ci) to ambient (ca)  $\text{CO}_2$  concentrations during photosynthesis. Numerous studies conducted later have shown the effect of the pollutants such as  $\text{SO}_2$  on  $\delta^{13}\text{C}$  values in annual rings of trees. Although the physiological mechanisms of the influence of these pollutants on the photosynthesis process are varied, the increase in their concentrations leads to the rise of the  $\delta^{13}\text{C}$  values by reducing the conductivity of the stomata or increasing the rate of carboxylation. Meanwhile, acid rains may lead to the reduction of  $\delta^{13}\text{C}$  by the inhibition of the carboxylation process, caused by chlorophyll degradation [2]. Carbon isotopic composition ( $\delta^{13}\text{C}$ ) in tree rings has been widely used to estimate temporal and spatial variations in intrinsic water use efficiency (iWUE), which is defined as the ratio of photosynthetic carbon assimilation (A) to stomatal conductance (g). Any change in carboxylation and/or stomatal conductance that altered ratio ci/ca is recorded as a change in  $\delta^{13}\text{C}$  and iWUE is driven by changes in atmospheric  $\text{CO}_2$  and pollutions [3, 4].

Presented results concern measurements of  $\delta^{13}\text{C}$  on  $\alpha$ -cellulose extracted from tree rings of spruce and pine for Sudety and Suwałki region respectively. The selected research areas: Sudeten, Tatra and Suwałki represent regions with various intensification of anthropopression. The forest of the Sudeten mountains located on the east of "black triangle" and outside coal mining and industrial regions experienced massive tree death in the 1970s and 1980s. The Tatra mountains as a huge mountain barrier intercept a wide spectrum of air pollutants coming from various direction. A time span for investigations covers years 1850-2010 and 1850 - 2003 for mountains and Suwałki region, respectively. Samples of  $\alpha$ -cellulose were isotopically analysed in Gliwice Mass Spectrometry Laboratory using an EuroVector elemental analyser coupled to a continuous flow IsoPrime mass spectrometer.  $\delta^{13}\text{C}$  results are reported in per mil (‰) relative to VPDB standards. Each sample was run in triplicate, with analytical errors of 0.1‰ and for  $\delta^{13}\text{C}$ . Values of  $\delta^{13}\text{C}$  in tree rings were used for assessing changes in iWUE. In the case of  $\delta^{13}\text{C}$  increasing trend due to  $\text{SO}_2$  emission is observed in the years 1960 – 1990 and 1970-1990 for Sudeten and Tatra respectively. For Suwałki region this increasing trend is observed only for 1980-1986. Numerous studies have reported widespread increases in iWUE coinciding with rising atmospheric  $\text{CO}_2$  concentration over the past century. Investigations for Sudeten and Suwałki regions confirm that the intrinsic water use efficiency of trees increases as stomatal conductance decreases in response to elevated  $\text{CO}_2$ . Differences in iWUE, calculated from data sets include not only trend of  $\text{CO}_2$  concentration changes but also trend of  $\text{SO}_2$  concentration changes.

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## **Neolithic wooden wells from Czech republic, dating and their importance for landscape reconstruction**

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Spreading of first farmers after 7500 BP in central Europe is most important change of then society, so called Neolithic revolution or transition. One of the Neolithic phenomena is wooden well, which is connected to human redesigning domestic and public spaces. The wells reaching the underground water allow preservation of timber construction. This unique situations has potential for dendrochronological dating, preservation of organic materials and wide range of paleoecological evidence. We are analyzing of Uničov well (central Moravia) and Velim well (central Bohemia) excavated 2 years ago. Both objects are dendrochronological dated to time span 5278 to 5104 BC. Next well was discovered last year in eastern Bohemia in Ostrov, dating is back to 5250 BC. This site is situated on the periphery of Neolithic area, wooden object is outside of settlement, and close Neolithic settlement wasn't discovered yet.

Wet infill of Neolithic wells has advantage of rich and good preserve and quantity of plant remains like natural sites, but it has detail record of terrestrial species and cultivated plants. Human subsistence wasn't based only on crop plantation, but picking of broad spectra of wild plants.

Existing evidence confirm surviving of species of open habitats, including steppe elements from Early Holocene, or to Last Glacial. It was probably supported endured relatively dry continental climate. It allows continues existing of open habitats species through Middle Holocene, co called Holocene forest optimum and formation of synantropic plant communities and open habitats communities, which existence is condition of human activity. This is a last period of relatively small human impact on nature and it cold be considered like beginning of culture landscape.

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## **$^{14}\text{C}$ excursions in the available radiocarbon time-series**

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For some time now it is known that for at least last tens of thousands of years  $^{14}\text{C}$  concentration in the atmosphere changed rapidly in certain, short periods of time. The phenomena was discovered by Fusa Miyake. Other authors also investigated both occurrence of other so-called  $^{14}\text{C}$  excursions and their possible reasons. Till today a discussion about origin of this changes has not been concluded. Despite of the origin and nature of the excursions they should be of radiocarbon community attention because of the potential use in precise radiocarbon dating and problems occurring during when dating samples of single- to five-year resolution. This is specially important for interpretations of radiocarbon dating in archaeology. Previously published results of researches suggest that the changes have been observed for periods no longer than couples of years with the amplitude of several ‰ and rise time of a year or less. We made a query of available  $^{14}\text{C}$  time-series datasets as a potential data for excursions seek. We will also present results of the excursions search made with some digital filters and will evaluate statistical significance of our findings.

### **Acknowledgments**

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## **Poster presentations**

Poster no 1

**Chronological study of archaeological site in Wilanowo versus environmental changes**

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Selected charcoals, wood fragments and bones samples from archaeological multicultural site Wilanowo (Greater Poland) were radiocarbon dated. The results of those <sup>14</sup>C measurements have been compared with relative chronology basing mainly on the typology of ceramics and other artefacts. On the basis of the found artefacts, some stages of the primaeval and early-historical settlement have been distinguished, starting from the Neolithic period (25<sup>th</sup>-17<sup>th</sup> century BC), till the traces of settlements from late Middle Ages (15<sup>th</sup>-18<sup>th</sup> century AD) and the traces of settlements from the modern times (18<sup>th</sup>-20<sup>th</sup> century AD). Those periods were characterised by evident climatic fluctuations in Europe (Büntgen et al. 2011), what may directly affect settlement occupation continuity or hiatus.

Büntgen U, Tegel W, Nicolussi K, McCormick M, Frank D, Trouet V, Kaplan J.O, Herzig F, Heussner K.U, Wanner H, Luterbacher J and Esper J, 2011. 2500 Years of European Climate Variability and Human Susceptibility. *Science* 331: 578-582.



Poster no 2

**Radiocarbon dating of archived bone samples from Gánovce–Hrádok: A contribution to the Holocene settlement history of the site**

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We have investigated a re-discovered (2017) assemblage of nine bones from Gánovce (district Poprad), findspot Hrádok, a well-known archaeological and biostratigraphic travertine archive in the North Carpathians. Eight bones of this assemblage collected important regional researcher Dr. Michael Greisiger in 1904 and 1906.

The state of preservation of all bones indicated that the assemblage does not belong to the Late Pleistocene fossiliferous strata with Neanderthal remains (Sabol et al 2017, Viček 1969), but rather to later periods, most likely the Holocene, as the site has rich artefactual records from the Neolithic to Late Iron Age (Viček and Hájek 1963, Novotný and Kovalčík 1977).

According to osteological analysis, eight human bones of skull and postcranial skeleton belong to three individuals (MNI=3) and one small fragment of flat bone belongs to an animal. The most of human bones has well preserved collagen (C:N 3.3–3.5) with  $\delta^{13}\text{C}$  around -20.5 and  $\delta^{15}\text{N}$  around 9.01 per mill, testifying to the terrestrial  $\text{C}_3$  biom based diet. According to radiocarbon dating, the majority of bones represent two distinct chronological horizons: late 6<sup>th</sup>–earliest 5<sup>th</sup> millennia (Middle Neolithic) and first half of the 3<sup>rd</sup> millennium cal BCE (Late Aeneolithic). Both periods have been known at the site from archaeological artefactual records but the ritual manipulation with human remains was known here only after 1680 cal BCE (Barta 2008).

Our research has brought direct evidence for manipulation with human bones at Gánovce-Hrádok in late 6<sup>th</sup>–earliest 5<sup>th</sup> millennia and first half of the 3<sup>rd</sup> millennium cal BCE. Even though the survival of six human bones from Baden/Post-Baden could be of solely taphonomic reasons, their presence seems to corroborate the occurrence of typical drinking Baden/ Post-Baden cups at the site (Novotný and Kovalčík 1977). Accordingly, we view these eco- and artefactual evidence as converging arguments to the ritual character of Hrádok travertine mound in 3000–2600 cal BCE.

Our research has brought also information on the local hydrogeology: radiocarbon dating of the animal bone partly embedded in travertine dates the activity of the mineral spring to the 14<sup>th</sup>–13<sup>th</sup> millennia cal BCE.

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Poster no 3

**A new statistical model of the chronology of the settlement Wolin , Trench 6/1660 based on radiocarbon dates, dendrochronological dating and stratigraphic and historic data**

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At the end of the 1980s and early 1990s, an attempt was made to develop a settlement chronology in the Wolin Settlement and navigation at the Odra estuary based on radiocarbon dates of 32 samples from the settlement itself and other archaeological sites of the Szczecin Seashore. Among the analysed material were also 17 dates from the trench 6/1660. In 2003 in the journal *Geochronometria* an article by Michczyński and Pazdur was published, which presented the results of the first attempt to develop the chronology of the Wolin Settlement trench 6/1660 based on <sup>14</sup>C dating results, but also taking into account information resulting from the stratigraphy of the excavation surveyed. The aforementioned chronology model of the settlement of Wolin, trench 6/1660 was then modified in 2011.

The stimulus for the development of a new model of chronology of the settlement of Wolin, trench 6/1660, was archaeological research, during which it was found that the assumptions regarding chronological relations between the time intervals associated previously with particular "cultural layers" were not entirely correct. The new model uses statistical analysis tools based on the Bayesian theorem. As input data were used not only the results of radiocarbon dating from the eighties, but also new dating of previously collected samples. In addition, the statistical model includes adjusted stratigraphic data and dendrochronological and historical dating.

Poster no 4

**Dating of charcoal hearths and dam remnants associated with historical water-powered metallurgy (Southern Poland)**

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The first documented use of a water wheel for iron smelting comes from France and dates from the beginning of the 12<sup>th</sup> century. A few historical sources suggest that water-powered ferrous metallurgy in Poland started in the 14<sup>th</sup> century or even earlier. Until the 19<sup>th</sup> century, the basic fuel used in metallurgy was charcoal. The main remains of historical charcoal production are charcoal hearth remnants. Relict charcoal hearths are round or elliptical earthen platforms from 12 up to 19 m in diameter, and tens and even hundreds of thousands of charcoal hearth remains have been found so far. The more rarely occurring remnants of historical water-powered metallurgy are earth dams in the bottoms of valleys. The dams were used to retain water in smelter ponds and to drive waterwheels.

The aim of this study was to perform radiocarbon dating of selected remnants of tens of charcoal hearths and a few earth dams located near historic centres of water-powered metallurgy and, if possible, to compare the dating results with historical data. The study was performed along selected courses of rivers in southern Poland with rich metallurgical traditions. We took samples from the landforms left by the charcoal hearths and dams which were previously identified using GIS. Soil profiles were prepared for each selected former charcoal hearth. If a charcoal and/or a coal dust layer was present in soil profiles then it was assumed that a charcoal hearth had certainly functioned at the site in the past. An exposure was made in the central part of each dam to reveal the structure of the material from which it was built. Fragments of charcoal from relict charcoal hearths and dams were taken for radiocarbon dating. Most of the radiocarbon dates obtained for the charcoal hearth and dam remnants analysed correspond well with historical data on the development of the nearest individual smelting centres. However, in some cases radiocarbon dates can serve as indications that the smelting plants may have been established earlier than historical sources suggest, or that the charcoal hearths and dams were used for another kind of activity.

**Poster no 5**

**Radiocarbon AMS dating and stable CN isotope composition of Mesolithic human remains from Poland**

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Biological studies on Mesolithic human remains from the Polish region are a rare subject of scientific research due to the limited number of these relics and their poor state of preservation. From the project titled “Old material with new methods: Using the latest bio-chemical analysis in studies of Mesolithic human remains from the Polish areas”, the radiocarbon dating of bones using accelerator mass spectrometry (AMS) has been performed (Piotrowska et al. 2019). For these experiments, the gelatin was extracted from bones, and its quality evaluated by the carbon and nitrogen content, and C/N atomic ratio. The stable isotope composition of both carbon and nitrogen was also determined.

The results have been obtained for 11 bone samples from 5 sites, and throughout this work the results of two preparation methods were compared. Only 7 of the investigated bone samples yielded ages within Mesolithic period, and the most reliable dates range from 5800 to 6800 cal BC. One sample was not datable, and two were shown to be much younger than expected.

Additionally, analysis on bones from Fifth and Sixth International Radiocarbon Intercomparison (VIRI/SIRI) were conducted. Despite the disputable result for the VIRI E sample, which proved to be problematic for many laboratories, the demonstrated reasonable <sup>14</sup>C background level allows to expect our results to be accurate.

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Poster no 6

**Early Neolithic site in Trzciano – a case study about Mesolithic settling episode**

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Site no. 40 in Trzciano, Wąbrzeźno commune, Northern Poland provides various archaeological finds related to the Mesolithic and Neolithic cultures. It is an extraordinary archaeological site mostly because of well-preserved organic finds. In the archaeological record of the past occurrences, there are some intriguing premises suggesting hunter-gatherers carrying Mesolithic traditions occupied the site after the Linear Band Pottery community left their settlement. Next, the Late Linear Band Pottery/the Stroked Band Pottery group settled the site. Therefore, Trzciano site brings a rare opportunity to take a glimpse on settlement patterns of both theoretically confronting groups (hunter-gatherers and farmers) in relation to one another. The number of existing radiocarbon dates for mentioned archaeological cultures is not high, although when one reflects upon the Chełmno land, it is in a considerably better situation than in some other regions, not only in Poland. As the Early Neolithic groups connected to Linear horizon are dated between 5600 to 4300 calBC, speaking roughly, the last groups of the Mesolithic hunter-gatherers are expected to survive within their tradition into the Early Bronze Age. Unfortunately, there are mostly no absolute dates obtained for the Mesolithic groups after the appearance of farmers on the Polish lands.

Therefore, a series of radiocarbon dates was conducted from materials excavated on Trzciano site. As for the sampling material the first choice were animal bones, because of the excellent state of preservation. After receiving the first results, charcoals were also sent. Contrary to antler and bone finds, charcoals and other plant-related ecofacts were gained in a much lesser amount from Trzciano site. In total, there were seven samples sent for radiocarbon dating. Even without applying Bayesian modelling, just by eye, the bone-sourced dates seems to be altered in some ways, not only compared to charcoal dating results but the general knowledge about Early Neolithic cultures in Northern Poland. It seems that conditions that let organic materials to last till modernity, also caused changes in mineral composed of bones, leading to wrong results of <sup>14</sup>C measurements. Therefore only reliable radiocarbon dates were obtained from charcoals and are only correlated to Neolithic phases of site occupation. Nevertheless, after applying various scenarios of events into Bayesian modelling, some remarks about site development can be stated more clearly. That also leads to the conclusion of more complex and dynamic changes in the final stages of the Early Neolithic on Chełmno land as well as habitation habits of Mesolithic hunter-gatherers next to farmers. Moreover, it gives some circumstantial evidence on a chronology of the Late Mesolithic groups.

The research was part of "Mesolithic communities in the Chełmno-Dobrzyń Lakeland. A settlement enclave in Ludowice" funded by National Science Centre (no. N N109 226140).

Poster no 7

**Interpleniglacial of Central and Southern Poland in the light of statistical analysis of radiocarbon and luminescence dates**

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A large convergence with the NGRIP curve has been demonstrated by studies on changes in fluvial environment conditions in southern Poland - Oświęcim Basin, Sandomierz Basin and Carpathians (Gębica et al. 2015; Starkel et al. 2015, 2017).

At present, the works have been extended to the areas of Central Poland Lowlands and highlands in Southern Poland. Radiocarbon and luminescence data originating mainly from river works were used for analyzes. Radiocarbon data were calibrated (OxCal - Bronk Ramsey 2009; IntCal13 - Reimer et al. 2013). The total density distributions probability in radiocarbon data supplemented with palynological information and luminescence date distributions are presented against the background of the NGRIP curve.

In the analyzed areas, the lack of radiocarbon data from the time corresponding to LGM is marked. This confirms the harshness of climatic conditions on the closer and further foreland of the ice sheet. There was also a record of a sharp transition towards periglacial and continental conditions ca. 33-30 ka BP (end of MIS 3). This is synchronous with the beginning of the expansion of the Scandinavian ice sheet. Part of the research areas is also expressed by the accumulation of loess on river terraces. In small valleys, or insulated minor depressions, only 2-3 "climatic" phases were found, which may be related to local morpho- and topographic conditions. In larger valleys in South and Central Poland there is a greater number of climatic changes. The issue of the speed of changes in the plant cover in the wake of episodes of warming or cooling remains open - there are no sites with long palynological records from the research area. Our investigations may provoke a new opinion on a fast expansion of tundra-forest during Interpleniglacial.

Poster no 8

**Record of climate change and anthropopressure in Central Poland (a case study from Pacynka river valley in the vicinity of Radom)**

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The organic sediments filling the Pacynka river valley near Radom constitute an interesting archive of changes in the natural environment during the Holocene period. Facial variability of the studied sediments is the result of climate change and progressive anthropopressure. In older parts of the Holocene, the formation of deposits was determined by changing climatic conditions, whereas in the last several thousand years, human economic activity played a significant role outside the mentioned factor. Separation of the impact of these two main factors on geomorphological and geological processes is often very difficult but possible using the interdisciplinary research methods. The 2.5 meter thick core of the deposits representing the Holocene sedimentation has been studied in great detail (among others, facial variability, radiocarbon dating, geochemical analyzes and stable C and N isotopes) what allowed to determine the main sedimentation phases and valley bottom development stages caused both by the climate changes and human economic activity in the Holocene - e.g. periods of deforestation, implementation and development of agriculture or breeding, bronze and iron age metallurgy, functioning of local mill ponds or development of industry in the 19<sup>th</sup> and 20<sup>th</sup> centuries.



Poster no 9

**Holocene radiocarbon chronology of debris flows in the eastern periphery of Chuya basin, SE Altai, Russia**

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Altai Mountains are the northern segment of the Central Asia collision belt. They stretch northwest more than 1500 km across the borders of Mongolia, China, Kazakhstan, and Russia, and form a wedge shape narrowest in the southeast and widest in the northwest. The highest and most seismically active southeastern part of Russian Altai (SE Altai), presented in this study is characterized by highly dissected topography, wide variability of climatic conditions and landscape dynamics. The SE Altai is studied unevenly. In contrast to the easily accessible vast intermountain depressions and major river valleys, mountain ranges and hardly accessible highlands within the peripheral parts of the intermountain depressions are significantly less investigated. Among them is the small Boguty basin. It is located within the eastern periphery of the Chuya intermountain depression and the western side of the Chikhachev range.

Area of investigations is characterized by arid severe continental climate. The sub-longitudinal position of the Chikhachev range on the eastern edge of the Altai mountain uplift determines the increased sensitivity of all nature systems to even small changes in temperature and precipitation. The wide distribution of glacial deposits, good preservation of landforms and presence of natural outcrops with the sediments suitable for radiocarbon dating makes it a key area for reconstructing of the late Pleistocene-Holocene landscape evolution and climate changes within the SE Altai and clarifying its role in the paleoenvironment evolution of Central Asia.

Studying post-glacier dynamics of landscapes in the region revealed that slope mass wasting processes play an important role among all surface processes within the Boguty basin. Debris flows were quite common nature phenomenon here. Together with climatic factors (rapid snow melting, permafrost degradation etc.) earthquakes could serve as a trigger of such events. Generally, seven sections of late Quaternary deposits were studied, and 23 radiocarbon age estimations were obtained as a part of multidisciplinary investigations, including geological, geomorphological, sedimentological and geochronological analyses. <sup>14</sup>C-ages of peat layers, fossil soils, lacustrine gyttjas and charcoal fragments suggest some chronological benchmarks of intensification of slope activity in the region. Prolonged periods of tectonic quiescence and slope stability in the first half of the Holocene occurred about 11000-8000 and 7000-2700 cal years BP. Debris flows took place at 8000-7000, 2900-1000, and about 650, and 250 cal years BP. The last such event was triggered in 2017.

Study was partly funded by Russian Foundation for Basic Researches (grant 18-05-00998).

Poster no 10

**Evaluation of the sedimentation rate of Czaple oxbow lake (Sieciechów area, central Poland)**

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On the basis of interdisciplinary research methods such as historical data, radiocarbon dating, variability of Cs-137 and Pb-210 activity or geochemical features of sediments, the rate of deposits sedimentation in the oxbow Czaple Lake was determined. Despite the considerable homogeneity of sediments filling the bottom of the oxbow lake, it was possible to separate the sediment core into the levels corresponding to changes in the human economic activity in the vicinity of this lake during the last several hundred years.

Poster no 11

**Late glacial palaeoenvironmental changes in the southern Holy Cross Mountains based on the “Białe Ługi” peatland record**

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This poster presents the late-glacial stage of the development of the Białe Ługi peatland in the southern Holy Cross Mountains, based on a comprehensive palaeoenvironmental data. A combination of palynology, Cladocera, sedimentology, sediment geochemistry analysis and <sup>14</sup>C were used. The results suggest the beginning of organic sedimentation should be associated with the Oldest Dryas. The sedimentary record of the aquatic and terrestrial ecosystems reflects a considerable difference between cooler phases (the Oldest, Older and Younger Dryas) and warmer phases (the Bølling and Allerød) of the Late Glacial. Periods of intensified interaction between aeolian processes and peatland have been related to stages of disappearing vegetation and changes in aquatic invertebrate communities. We therefore suggest that the peatlands were created as a result of the area's local lithological-structural, tectonic, hydrogeological and morphological conditions, and the peatland's development rate was largely influenced by changing climatic conditions, which determined local vegetation development, intensity of denudation processes and water level changes. The results show the significance of the selection and use of several methods, as well as the value of the biogenic deposits from the Białe Ługi peatland as archives of past climate change in the Małopolska Upland.

Poster no 12

**Spatial distribution of  $^{137}\text{Cs}$  in bottom sediments in Turawa and Koronowo lakes after 32 years since the Chernobyl power plant accident**

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Chernobyl nuclear power plant accident in 1986 caused radioisotopes pollution (including cesium-137) in a large area of Europe. The recent research has shown that due to the relatively long half-time of  $^{137}\text{Cs}$  decay (30.08 y), its migration and accumulation in the natural environment may be observed even after 32 years from the Chernobyl fallout. In addition,  $^{137}\text{Cs}$  research has been significantly developed due to its harmful effects on health, but also due to its suitability for dating, e.g. lake sediments.

The main goal of this study was to determine the spatial distribution of  $^{137}\text{Cs}$  in lake sediments (0-5 cm depth) in Turawa Lake (50°43'19"N; 18°07'42"E) and Koronowo Lake (53°20'17"N; 17°57'39"E) after 32 years since the Chernobyl fallout. Furthermore, the purpose of this research was also to compare the  $^{137}\text{Cs}$  activity in bottom sediments in dam reservoirs located in areas with different levels of pollution with this radioisotope.

Studied reservoirs are characterized by similar limnological features, however, they are situated in regions where various concentrations of cesium radioisotopes were detected. According to the previous research, it is known that Turawa Lake is located in a heavily polluted area (a.k.a. Opole anomaly), oppositely to Koronowo Lake.

In order to determine the spatial distribution of radiocesium in surface sediments (0-5 cm depth) in Turawa and Koronowo lakes, the  $^{137}\text{Cs}$  and  $^{40}\text{K}$  activity were measured using low-background, high purity germanium (HPGe) coaxial detector. In addition, the elemental analysis (C, H, N and S) in collected samples was also performed using Vario CUBE elemental analyzer.

The measurements showed that  $^{137}\text{Cs}$  activity in bottom sediments in studied reservoirs is still significant. Higher activity concentration of this radioisotope was found in fine-grained (<0.063 cm) than in coarse-grained sediments. The similar relationship was registered for  $^{40}\text{K}$  measurements. Additionally, the positive correlation between  $^{137}\text{Cs}$  activity and organic carbon content in the collected samples also been noticed. Based on obtained results, processes determining the spatial distribution of  $^{137}\text{Cs}$  in bottom sediments, as well as its eventual possibility of migration in the selected lakes' ecosystems have been analyzed.

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Poster no 13

**Pb-210 chronologies of young peat profiles sampled with low frequency**

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The dating method using the radioactive  $^{210}\text{Pb}$  is widely applied for dating geological sediments in the environmental research. It is one of the fundamental and leading methods allowing the determination of the chronology of samples whose ages do not exceed approximately 150-200 years (the range of the method is determined by the half-life of  $^{210}\text{Pb}$  –  $T_{1/2} = 22.6$  years). The paper presents the results of measurements of the specific concentration of lead-210 for six peat profiles representing three peat bogs from two regions of Poland (Silesian Upland, Poleski National Park) and the problem of creating the age-depth models. For the construction of age-depth models, it is proposed to use mathematical functions, the best fit to the measured activity. The F statistics were used as the measure of the match quality. Matching the best mathematical function was determined for each of the cores independently, by the application of the measured specific activity of unsupported  $^{210}\text{Pb}$ . The obtained models were visualised in two ways - showing the age calculated on the basis of direct measurements of activity and indicating points that are the results of the used approximation. Additionally, the proposed models were compared with the models obtained by using SIT, Mod-Age, OxCal, Clam, and Bacon programs.

**Poster no 14**

**Calibration transfer between alpha sources using different samples and protocols**

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Calibrating the dose rate of radioactive sources used for OSL dating is ultimately important to determine precisely the equivalent dose of samples investigated. Concerning routinely used beta sources, calibration is usually made by using coarse, and more recently also fine grain, so called calibration quartz samples. These are subjected to a SAR measurement, and based on the known gamma dose previously irradiated to the sample, the dose rate of the unknown beta source is calculated.

On the other hand, the calibration of alpha sources is less straightforward at the moment, since for the calculation of dose rates the efficiency of alpha irradiation in comparison to a beta or gamma irradiation of identical energy has to be known as well. This efficiency parameter, termed a-value, has not been published for commercially available calibration samples yet, such as the RISØ fine grain calibration quartz. The primary way of alpha source calibration is through determining the number of particles per unit volume per unit time delivered to a phosphor sample using a weak alpha source and a surface barrier detector, then comparing the induced luminescence to that received by using the source and separation distance to be applied for the measurements later. Another approach, requiring less facilities, is the transfer of calibration from a primarily calibrated source to a source of unknown dose rate by the means of different dose recovery measurements. In the present study we attempted to transfer calibration from two already calibrated alpha irradiating facilities situated in the Bayreuth Luminescence Dating Laboratory (an upgraded RISØ TL/OSL DA15 type luminescence reader and a Littlemore 721/B type six-seater irradiation facility), to an alpha source mounted on a RISØ DA-20 luminescence reader at the Szeged Luminescence Dating Laboratory. Each facility is equipped with Am-241 sources. Two fine grain quartz samples (a fluvial silt and the fine grain RISØ calibration quartz – Batch 108) and 3 different approaches were applied through the procedure. Concerning the first two approaches multi-dose-point (including a zero-dose-point) measurements were made instead of the usual single-dose-point calibration transfer.

First, sun lamp bleached aliquots irradiated at Szeged with incrementally increased unknown alpha doses were recovered on the Bayreuth RISØ reader using an alpha SAR (Single Aliquot Regeneration) protocol. Then, another set of bleached aliquots, a subset of which were irradiated with the Bayreuth Daybreak facility were subjected to an alpha MAR (Multiple Aliquot Regeneration) measurement with an equal predose normalisation at Szeged. Finally, unbleached aliquots of the RISØ calibration quartz carrying a 4.81 Gy gamma dose were recovered at both laboratories with RISØ luminescence readers using alpha SAR measurements again.

Results showed a good consistency regardless of the applied procedure, alpha dose rates were very similar and fall within the errors received for the different procedures. Consequently, the calibration was transferred successfully from Bayreuth to Szeged, and the RISØ calibration quartz seems to be an adequate material for simple calibration transfer between laboratories.

Poster no 15

**Investigations of the traps responsible for OSL fast component in quartz using TM-OSL method.**

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The main stipulation of luminescence dating of sediments is the OSL signal zeroing prior to the deposition of mineral grains. Due to this requirement, it is believed that the fastest decaying component of the OSL signal is the most suitable for age estimation. Nevertheless, the nature of the OSL signal of minerals is usually complex. This is also the case for quartz, so there is a need for an experimental method that allows the effective separation of the fast OSL component in optical dating procedure. Recently, it was found that the fast OSL component can be separated from other components of OSL signal in quartz when so-called thermally modulated OSL (TM-OSL) method (the optical stimulation during the linear heating of sample) is conducted using the light with the wavelength of 620 nm [1]. The relation of the observed TM-OSL signal with the fast component observed in CW-OSL and LM-OSL measurements were confirmed *inter alia* by the finding that the same TL peak is bleached as a result of measurements of both kinds of signals. It was established by measuring the difference between the TL curve obtained directly after the irradiation and thus obtained after the irradiation and the TM-OSL signal measurement. The TL signal bleached during the TM-OSL measurement turned out to be composed of two first-order kinetics peaks which seems to suggest that two kinds of traps are responsible for the fast component in quartz.

The main aim of this work is verifying the origin of the OSL fast component. The TL signal bleached during the TM-OSL measurement was investigated using the various heating rate method. This allows estimating values of the thermal activation energy  $E$  and the frequency factor  $s$  for the dominant TL component. Next, the TL signal bleached during the TM-OSL measurement was analyzed by the fitting procedure. A sum of two first-order kinetic peaks was fitted to an experimental curve using, for the dominant peak of the trap, parameters obtained from the various heating rate method. The dependence of the intensities of both TL components on the time of optical bleaching, on the wavelength of light used for bleaching as well as on the temperature of preheating prior to TL measurement was tested.

In order to verify the obtained results, two types of quartz sediments of various origin were investigated. Measurements were carried out using Risø TL/OSL system TL-DA-12 equipped in an external stimulation module delivering light of 660, 620 and 530 nm. TL was measured in two detection spectral ranges: 335 – 345 nm and 350 – 450 nm.

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Poster no 16

**Generation of UV-induced radiation defects in calcite**

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The effect of UV light on the most common mineral on Earth – calcite ( $\text{CaCO}_3$ ), has been little investigated, despite its significant implications for many areas of research, such as dating of archaeological and geological materials, conservation of cultural heritage and photodegradation of  $\text{CaCO}_3$ -containing materials. In this study, conducted on nano- and micro-grained calcite samples using Electron Paramagnetic Resonance spectroscopy and Scanning Electron Microscopy, we provide a detailed analysis of the radiation defects (paramagnetic centers) generated by UV radiation, including their identification, location (surface- or bulk-related) and stability during the period up to 4 years after irradiation. The observed paramagnetic centers, such as isotropic and anisotropic  $\text{CO}_2^-$ ,  $\text{CO}_3^-$ ,  $\text{SO}_2^-$ ,  $\text{SO}_3^-$ ,  $\text{NO}_3^{2-}$  and  $\text{NO}_2^{2-}$  ions, are analogous to gamma-induced species, which contradicts a widely-held belief that low-energy radiation cannot create radiation defects in wide band-gap materials, such as calcite. We present a mechanism of UV-induced generation of carbonate paramagnetic species in calcite based on retrapping the ‘secondary electrons’, i.e. the electrons released from non-carbonate traps by UV light. The efficiency of this process is strongly connected with the size and morphology of calcite grains, which can be especially relevant, considering the variety of  $\text{CaCO}_3$  particles available in nature and in man-made objects.



Poster no 17

**Radiation defects in lime mortars and plasters studied by EPR spectroscopy**

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Electron Paramagnetic Resonance (EPR) spectroscopy is a well-established method of dating based on trapped charges, applied to various crystalline materials, including carbonates, bones and teeth. It provides a detailed insight into the structure of radiation defects – paramagnetic centres generated by irradiation, without the need of a painstaking sample preparation, often challenging in other methods. Using EPR we studied the effect of gamma radiation on lime mortars and plasters from two archaeological sites: Sveta Petka church in Budinjak, Croatia and ancient settlement Hippos in Israel, in order to analyse the process of defect generation occurring naturally in time during sample history. Analysis of the complex spectra revealed the presence of radiation-induced species of carbonate origin, as well as those connected with additives and impurities, such as sulphates and nitrates. Since, as it has been recently shown, radiation defects can also be generated, instead of bleached, in pure calcite by UV radiation, we investigated also the effect of UV exposure on lime mortars. Our results can lead to deeper understanding of generation and bleaching mechanisms of paramagnetic species, which is crucial for identifying the issues, especially related to light exposition, affecting the accuracy of age determinations in trapped-charge dating methods.

Poster no 18

**Determination of electron trap parameters based on isothermal measurements performed using the TM-OSL method**

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Possibility of extracting the individual OSL components during the experimental stage is important in OSL dating of sediments, where using the component that is most easily bleached during the transport of grains before the deposition is the prerequisite for correct results of the age estimation. Recently it has been shown that the thermally modulated optically stimulated luminescence (TMOSL) method, which is based on optical stimulation during linear heating of the sample, is a good method to successfully obtain this result [1]. The TM-OSL measurements help also to correlate the optical depth of a trap with its thermal depth which enables to determine the thermal stability of traps active in the OSL process. This is especially significant in thermochronometry where the prediction of the temperature and time dependence of the stimulation processes in mineral grains is the main problem.

In previous works, it has been showed that the fast component of OSL in quartz can be separated from the others by optical stimulation with the wavelength of 620 nm [2]. The slower OSL components in quartz can be measured individually using the TM-OSL method after a prior gradual removal of the signal from the shallow trap states. The components medium and slow are obtained with the wavelengths of stimulation light in the range 500–540 nm and 450–460 nm respectively during the linear heating up to 200 °C. The thermal stability and dose response characteristic were investigated independently for the individual OSL components. The fast component in quartz from sediments is close to saturation for the doses about 300 Gy whereas other components are not in saturation for doses about 3 kGy. When using the method of pulse annealing (measuring the remnant OSL vs. preheat temperature) the fast OSL component turns out to be more thermally stable than the medium and slow components [3].

Here the results of pulse annealing method are compared with results obtained by an isothermal decay experiment. After irradiation, samples were held at fixed temperatures (in the range of 240 to 280 °C) for 0 to 10 000 s prior to TM-OSL measurement of the individual OSL component. Isothermal measurements allow to determine parameters of the electron traps (the thermal activation energy and the frequency factor) responsible for a particular component of the OSL signal. Measurements were performed for grains with a diameter of 100–200 μm separated from sediments of various origin and various mutual relations of the intensities of the individual OSL components.

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Poster no 19

**Luminescence properties of single grains of quartz**

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Potentially, each grain of quartz has different luminescence properties like the shape of the OSL decay curve, shape of TL glow curve, intensity of luminescence emission, change of sensitivity upon heating. This fact has implications for the interpretation of the luminescence signal recorded for aliquots composed of several grains, not only in the application to luminescence dating but also in attempts to explain the physical processes responsible for the luminescence production. Here we show examples of such differences for a few selected samples and discuss the implications.

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Poster no 20

**Luminescence dating of Holocene soil erosion (Lublin Upland, E Poland): testing new approach to dose rate determination**

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These loess in Poland was accumulated in the Pleistocene in the periglacial zone, and their accumulation had already finished by the end of the Pleistocene. Nowadays, loess is a widespread Quaternary sediment in the world. The phase of intensive modelling of the land surface by slope processes lasted from the finish of the loess accumulation. At the end of the Pleistocene, the loess areas of Poland were covered by the vegetation of cold steppes and steppe-tundra, whereas in the Holocene – by the formations of evergreen forests. Thus, even before the beginning of the Holocene, the surfaces of the loess areas were being stabilized by the gradually emerging vegetation cover. From the end of the accumulation of loess deposits to the beginnings of the Neolithic settlements, natural forest vegetation limited the processes of water erosion of soils on the slopes. In the early Holocene, the loess areas were uninhabited. The Neolithic agricultural cultures damaged the natural plan cover and thus increased a slopewash processes. Precise establishing age of loess cover as well as products of water soil erosion is vital for palaeoenvironmental studies.

This work presents results of detailed analysis of slope sediments and loess cover from the Kolonia Celejów site (Nałęczów Plateau, Poland) by the luminescence dating. Beside this sediment samples were collected for radioactivity analysis with three independent methods: gamma spectrometry, thick source alpha counting (TSAC) and  $\mu$ Dose system. The results obtained with gamma spectrometry and  $\mu$ Dose system are quite similar whereas the results obtained by TSAC tend to be substantially higher. We proposed a new approach in calculation of dose rate. Simultaneously using at least two independent techniques to determine the dose rate with increased precision and accuracy.

For luminescence dating 14 samples samples from two sediment profiles were collected. The blue light luminescence dating and SAR protocol were performed on the medium grained quartz fraction (90-125  $\mu$ m). The selected sediment profile was modified by pedogenic processes, postpedogenic redeposition and secondary accumulation as the colluvial layers. In this study simultaneously with luminescence dating detailed pedagogical and micromorphological studies were performed. Those additional analysis allow to recognize the litho- or pedological microfeatures in the examined profiles and thus improve the interpretation the luminescence dating results. This results are important for the study of Holocene soil erosion and accumulation of colluvial sediments not only in local scale but also in wider range eg. for the loess uplands of Central Europe.

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Poster no 21

**Luminescent properties of microcline from the granite pegmatite of the Strzegom Massif**

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Feldspars, which are more than 50% of the earth's crust, is widely used in ionizing radiation dosimetry, especially for luminescence dating. Microcline as a potassium feldspar is a good detector of ionizing radiation. However, its luminescence depends on many factors. The influence of the type of stimulation on the luminescence signal of microcline crystals was investigated. Measurements were made using custom made OSL Helios readers [1] with green and IR stimulation. In the first stage the samples were irradiated with doses from ~ 1 Gy to ~ 3000 Gy. Irradiation was performed using a  $^{90}\text{Sr}/^{90}\text{Y}$   $\beta$  source. Then OSL and IRSL signal was measured for 3 series of different samples. Fading and regeneration [2] studies were also carried out.

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Poster no 22

**Luminescence dating of tsunami-laid sands in Lake Huelde (south-central Chile): methodology acknowledged**

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We summarize the results of an explorative study into the potential of luminescence dating techniques for application to tsunami-laid sands in the coastal Lake Huelde (south-central Chile). The investigated samples were taken from four sandy-layers in a cored sequence of about 5 m long.

The luminescence investigations used sand-sized grains of K-feldspar, the SAR protocol and signals stimulated with IR at 50°C (IR50). We document the characteristics of this signal in terms of recycling, recuperation, anomalous fading, and dependence of both equivalent dose and fading-corrected age on preheat temperature. It is concluded that a low preheat temperature (60 s at 80°C) is required to minimize significant age overestimation owing to thermal transfer. We find no evidence that higher preheat temperatures isolate a signal that is thermally more stable.

The distribution of equivalent dose, fading rate and fading-corrected age was then examined in each of the four samples. Broad distributions were observed for all samples. Apart from a few outlying values, the corrected age distributions in the two lowermost samples appear to belong to a single population. The spread observed in these samples (RSD: 20 %) was taken as a measure for the spread that can be expected for a well-bleached, undisturbed and unmixed sample; it was used to derive an age from the asymmetric distributions observed for the two uppermost samples. The fading-corrected IR50-ages are broadly consistent with the stratigraphic position of the samples and range from 0.174 ka to 1.64 ka. Interestingly, a slight age inversion is observed for the two lowermost samples.

We also examined the potential of a post-IR IRSL signal, which was obtained by stimulating with IR at 290°C following a stimulation with IR at 50°C (pIRIR290). While behaving well in the SAR protocol, and laboratory measurements confirm previous finds with respect to of signal stability, the pIRIR290-ages are about 6ka higher than the IR50-ages.

This contribution mainly aims at documenting the considerable methodological efforts and finds that underly the single IRSL date that was previously reported for the exceptionally long and continuous coastal lacustrine record from Lake Huelde.

Poster no 23

**Luminescence characteristics of natural building stones from the Falcon Monastery (Antwerp, Belgium): potential for establishing (de)construction chronologies**

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Over the past few years, luminescence dating of consolidated rocks (as opposed to loose sediments) has been revitalized, leading to new methods for unraveling their light exposure and/or burial history. In this study, we examine if the approach may aid in unravelling the (de)construction history of monuments built out of Lede stones. Lede stone is a sandy limestone, that has been widely used for stonemasonry in NW Belgium from the Roman times onwards.

The samples of Lede stone investigated here were collected during an archaeological excavation of the Falcon Monastery (Antwerp, NW Belgium). The Monastery has a rich building history, with various construction phases starting as early as the 14<sup>th</sup> century CE, until it was demolished (and buried) by Napoleon Bonaparte in the beginning of the 19<sup>th</sup> century CE. While some of the successive phases can be well constrained in time, it is unknown when some of the other buildings were added to the complex.

Given the mineralogical composition of the stones, the IR50-signal from feldspar was used and we document the characteristics of this signal (as observed from rock slices and using the SAR protocol) in terms of signal intensity, dose response, recuperation, recycling, and dose recovery. We assess completeness of resetting by examining the variability in Ln/Tn for single surficial slices taken from multiple cores in the same rock samples; the variation in signal with depth into the rock is investigated as well. We then use the Ln/Tn values, which are finite, to establish burial or deconstruction ages, while exposure ages are derived from the luminescence depth profiles. The accuracy of the former is assessed by comparison with the known demolition date, while that of the latter is evaluated by treating one of the known-age phases as an unknown.

Poster no 24

**The luminescence dating of the knight of Sarcus and the *plommure* finials from Beauvaisis province (France)**

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Intended to protect the timber frame assemblies from roofs, the finial is also a decorative architectural element designed to distinguish the social status of the owner of the dwelling. In the 13<sup>th</sup> and 14<sup>th</sup> centuries, the towers were decorated with weather vanes or figurine of lead or terracotta representing the lords who built the castles.

The knight of Sarcus is a piece of the MUDO-musée de l'Oise (Beauvais, France) collections representing a knight wearing a coat of mail, a helmet and armed with a sword, on a caparisoned horse. He is identified by Sarcus' coat of arms and is said to have adorned the roof of today's missing Sarcus castle. It is a lead-glazed terracotta (*plommure*) as we know it for the 16<sup>th</sup> century. However some authors date it from the 13<sup>th</sup>-14<sup>th</sup> centuries.

We were asked to make luminescence dating on this work in comparison with two ridge finials from the same collection. These two pieces representing musicians come from a house in Beauvais. They associate white and red earth. The first, damaged, plays the harp, the second, the hurdy-gurdy. Their costumes are characteristic of the 16<sup>th</sup> century.

Luminescence dating (BL-OSL, no OSL-IR and unusable TL) confirms that both musicians agree with 16th c. productions:

- The musician with lyre or harp (n ° 14.2) is dated between AD1470 and AD1610 ;
- The musician with the hurdy-gurdy (inv 14.3) is dated between AD1405 and AD1565.

On the other hand, the luminescence dating (BL-OSL, TL, absence of IR-OSL) of the Sarcus knight is not compatible with a 16th century production, but is in agreement with a 13<sup>th</sup>-14<sup>th</sup> century production.

- The Sarcus knight (Inv 860.6) is dated between AD1185 and AD1355.



Poster no 25

**Age of Danube terrace sediments on the Pest Plain (Hungary) based on optically stimulated luminescence dating of quartz and feldspar**

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The Danube terrace staircases in Hungary developed between the uplifting areas of the Transdanubian Range and the North Midmountains and the subsiding Little and Great Plains. Different uplift and subsidence rates and periodic climate changes affected the formation of the terraces during the Late Pliocene and Pleistocene. The chronology and correlation of the Danube terrace system in Hungary is based on the geomorphic position of the terrace segments (e.g. Pécsi, 1959), rare palaeontological findings, U/Th ages, magnetostratigraphic and sedimentological–petrological data, and recently cosmogenic nuclide (<sup>3</sup>He, <sup>10</sup>Be, <sup>26</sup>Al) dating and optically stimulated luminescence dating (e.g. Ruzsáczay-Rüdiger et al. 2005, 2018).

In this study, coarse grain (0.1–0.16 mm) quartz and K-feldspar of sand samples were dated by optically stimulated luminescence method. Samples were collected on the Pest Plain from six outcrops of the different terraces of the Danube. Equivalent doses were determined using SAR OSL protocol on quartz and post-IR IRSL (290 °C) on feldspar. Most of the samples were unsaturated and gave good results in the test measurements (dose recovery ratio, recycling ratio, recuperation). Residual doses of feldspar in the unsaturated samples were about 14–30% of their natural equivalent doses after 12 hours of sunlight bleaching.

Preliminary results indicate that in the southern part of the study area the fluvial gravelly sand layers of the V terrace of the Danube are too old for precise dating because their feldspar was saturated, and only the minimum age of the sediments could be determined. Based on their 2D<sub>0</sub> values they formed earlier than the MIS 7 period. The dated dune and fluvial sediments, which cover the IV, III and IIb terraces in the northern and central part of the Pest plain, were deposited during the MIS 3 and MIS 2 periods.

The new results give opportunity for the comparison of optically stimulated luminescence ages of quartz and feldspar of the same sediments, and serve additional data to the chronology and correlation of the Danube terrace system.

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Poster no 26

**The first Middle Pleistocene absolute dates of the Middle Volga and the Northern Caspian regions**

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The Caspian region is the largest paleoclimatic proxy of the Quaternary in Eurasia. Research of Caspian Sea is important for understanding the paleogeographic conditions of the Eurasian Pleistocene and global climate change. There is still no consensus about the number of transgressive-regressive stages, their causes, the level of high- and lowstands, chronology, conditions and correlation with climate changes in nearby regions.

Our research group focused on the sea-highstands research. During the transgressions there were formed ingressive gulfs along the valley of the Volga and smaller rivers. The key area of our study is located in the valley of the Maliy Karaman river (the left tributary of the Volga). There are two clearly visible terraces on the sides of the valley (+35 m and +50 m). Our research was focused on the +35 m terrace, because it was eroded by gully.

Terrace consists of: 1. beige sandy loam with modern soil (0-1.5 m); 2. thickness of sand with thin interlayers of clay every 3 cm (1.5-3.1 m); 3. thickness of sand (3.1-6.0 m); 4. sands with interbedded clay every 8-10 cm (6.0-7.5 m); 5. loess (7.5-13.5 m) with soil at depths 11.0-11.7 m. According to our supposition and previous data this terrace has marine genesis. A.I. Moskvitin (1962) found rare detritus and malacofauna *Didacna* genus (which is a stratigraphic marker of the Caspian region). However, the description of the species of *Didacna* is extremely poor. In the thickness of the aquatic sediments (layers 1–4) we did not find any fauna. We took samples for grain-size, XRF analysis and OSL-dating. According to our assumptions and previous data the terrace was formed during the one of the stages of the early Khvalynian transgression (MIS 2) of the Caspian Sea; highstand's age according to radiocarbon and OSL dating is 17-13 ka (Arslanov et al., 2016; Yanina et al., 2017).

Sediment was sampled in the opaque bags in the night. The samples were sieved to extract 90-180 µm fraction and then were treated with 10% HCl and 10% H<sub>2</sub>O<sub>2</sub> to remove carbonate and organic matter. For the separation of feldspar and quartz there were used heavy liquid with a density 2.58 g/cm<sup>3</sup>. Feldspar grains were washed and dried. Quartz grains were cleaned from clay with 10% HF, washed and dried.

All samples were processed and measured at the luminescence laboratory of the Karpinskiy All-Russian Geological Institute. Luminescence signals were measured with a TL-DA-20 automated Risø reader equipped with LEDs for stimulation and a <sup>90</sup>Sr/<sup>90</sup>Y beta source (dose rate, ca. 0.043 Gy/s) for laboratory irradiation.

The measurements were carried out on quartz; a plateau test and a purity test were performed. However, quartz was oversaturated. The measurements were carried out using feldspar according to the post-IR IRSL<sub>50/290</sub> protocol (Thiel et al., 2011).

The natural radionuclides were determined by a non-destructive gamma-spectrometric method using an ultra-pure germanium detector HPGe-3808 and Genie PC 2000 software at the Department of Radiochemistry, Lomonosov MSU.

Age calculations were performed using the DRAC Calculator (Durcan et al., 2015). There were obtained three dates from depths of 2, 7 and 8 meters. They correspond to MIS 8–9, 10, and 11 and early-Khazarian transgression. These are the first estimates of the age for the Middle

Pleistocene of the whole Middle Volga and North Caspian regions. Natural conditions during these periods were determined using grain-size and chemical elements ratios data.

Poster no 27

**Palaeoenvironmental analysis of Nowolesie gully sediments (Niemcza-Strzelin Hills, SW Poland)**

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Environmental paleoreconstructions of relief evolution from the beginning of Neolithic age (forest clearance, agriculture, cattle breeding and grazing) of loess region in SW Poland in geomorphological and sedimentological field are not very popular the human migration and settlement however are well described by archaeologists and historians. The papers on transformations of the relief created so far under the influence of human activity from the beginning of neolithisation in the Polish territories largely ignore the area of Lower Silesia. Therefore, in this aspect it is a "white patch" among the remaining loess areas of Poland, and the purpose of field research is to fill this patch. The created forms and sediments with the levels of fossil soils contain a record of temporal and spatial transformations of the relief due to land use by humans along with local climate changes. They form a kind of unique geo-archive.

The research was carried out in the loess areas of south-western Poland which are in forms of isolated patches, with particular reference to the Niemcza-Strzelin Hills. This region, which is a part of the Sudeten Foreland, is characterized by the occurrence of longitudinal stretches of hills, whose highest elevations exceed 300 m above sea level. The bedrock is made of gneisses, quartzites, quartzite and mica schists, marbles and amphibolites known as the Strzelin metamorphic. However, the most important element of the geological structure in terms of agricultural settlement is loess and associated fertile soils, which largely cover the slope and post-slope zones of the Hills. The selected area are characterized by the presence of a relatively continuous loess cover with quite considerable thickness (on average 3-6 m), and the presence of a set of relief forms typical for loess cover, in which the most spectacular element are gullies. A specific area of research included a gully located near the village of Nowolesie ( $\lambda$  17.05E  $\phi$  50.71N) on the western side of the slope of the Strzelin Hills.

Analyzes and laboratory tests were carried out primarily in the laboratory of ground science at the University of Wrocław and include: grainsize analysis of sediments (Mastersizer 2000), measurement of carbon content (Turin method), measurement of the content of anthropogenic elements in samples (geochemistry - Cu, Pb, Zn, Cd, Fe). In cooperation with the Silesian University of Technology, sediment dating (radiocarbon method <sup>14</sup>C, OSL method) was performed.

Each area or form studied has its own individual history in terms of the development of local human settlements, but all have common elements that define the phases of both increased human activity in a given area as its regress or permanent or temporary decline. The author distinguish several phases of erosion and accumulation depending on the studied area, correlate the results of dating with periods of increased human settlement and climate change.

The main task is to establish the number of phases (historical/archaeological) and to correlate them with obtained data from OSL and <sup>14</sup>C dating methods. Such studies, apart from capturing

changes that have occurred in area in the past and the present, can be very successfully used to predict the reaction of the environment to human activity in the future.

Poster no 28

**Simultaneously using dendrochronology study and radioisotopes measurement to study soil erosion in loess gully near Poręba village (South Poland)**

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Loess areas especially an agricultural areas are susceptible for soil erosion. The loess areas are susceptible for rill erosion and gullies formation. Although in the last decades studies on erosion at gullies has been carried out by researchers, few studies have specifically addressed the use dendrochronological analysis of roots in sediments or soil simultaneously with analysis of Cs-137 and Pb-210 radioisotopes in the same sediment or soil layers.

The use of fallout radionuclide Cs-137 affords an effective and valuable means of studying erosion and deposition within the landscape. Cs-137 technique has now been used to investigate soil erosion and sediment accumulation. Compare to Cs-137 there are only little papers about using Pb-210 to study soil erosion. This isotope is rather used to study lake sediment.

For this work a three series samples of samples from one of the numerous gullies of the Proboszczowicka Plateau (Poland, South,) were collected. This is a comprehensive study of soil erosion and sedimentation at gullies by two methods dendrochronology and radioisotopes Cs-137 and Pb-210. Moreover for all collected samples a grain size was established. The sediment samples were collected from the bottom of the gully, from the slopes /wall of the gully/ and from the undisturbed areas as a reference site. For all collected samples the activity of Cs-137 and Pb-210 were determined by the semiconductor gamma spectrometry.

Simultaneously from the bottom of the gully and slopes were collected the samples to dendrochronology study. To dendrochronology study were collected samples of roots growing within depositional landforms in the gully bottom as well as roots samples from the slopes (sidewall) of the gully.

To determine the age of the roots, it was assumed that it equals the minimum age of particular sediment horizons. In case of eroded sidewall of gully we determined by the time at which the roots were exposed by soil erosion.

Results of the study indicate that analysed landforms developed during the last 50 years. Diverse age of roots growing in sediment horizons allowed to determine at least 3 significant geomorphic events resulting in deposition of material in the gully bottom during the last 50 years. This suggests that relief of gullies could be shaped surprisingly fast, despite forest cover contemporary occurring there.

Studies confirmed the potential value to use dendrochronological analysis of the age of roots growing within dated sediment horizons or exposed roots on eroded slopes simultaneously with analyses of <sup>137</sup>Cs and <sup>210</sup>Pb in sediment or soil.

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Poster no 29

**The geomorphological dynamics of the forested slope in the light of the activity level of  $^{137}\text{C}$ ,  $^{210}\text{Pb}_{\text{ex}}$  and  $^{14}\text{C}$  radioisotopes**

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The forested mountain slopes of Southern Poland were relatively often transformed by landslides, sheet-wash and linear water erosion along mountain watercourses, forest roads and tourist tracks. Also, an indelible mark of his activity was left in this area by a man. Recently the role of tree uprooting in the denudation of forested hillslopes was also proved. The forest covering the slopes is also the domain of accumulation of transported material in a situation where there is a subalpine and alpine floor zone above the upper forest border and the tree border. These floors zones can be the source of the weathering material originated as a result of frost processes. In the presented study, we hypothesized that the slope cover material within which the forest soil profiles developed was transformed or transported primarily as a result of bioturbations (pedoturbations). The process that can have the greatest impact on pedoturbation is the process of tree uprooting (e.g. caused by strong wind). In this work we present results of studies on geomorphological dynamics of the forested slopes in the light fallout radionuclides. As a study sites two slopes located in the Gorczański National Park and Babiogórski National Park were selected. From these slopes we collected 23 soil and sediment cores. Additionally, soil cores from the reference sites – areas where no soil erosion or sediment accumulation occurs, were obtained. The samples were collected with the use of a manual soil auger (5 cm in diameter, depth up to 50 cm) and a soil sampler driven by a combustion engine (10 cm in diameter, 1 m deep). The following sampling scheme was adopted: 1) reference cores from logs within the ridge or flat area, 2) short cores along the slope transect according to its inclination, 3) cores within treethrow pits and from the adjacent undisturbed slope (control cores). At the laboratory stage activities of fallout radionuclides were measured by the semiconductor gamma ray spectrometry. Moreover, in order to assess the level of soil erosion and sediment accumulation based on radioactivity data a global fallout was calculated based on precipitation data. For the age determination of certain soil horizons charcoals were extracted and the activity of radiocarbon  $^{14}\text{C}$  was measured by AMS (Accelerator Mass Spectrometry) and LSC (Liquid Scintillation Counting) method. Additionally, for each of the samples, grain size by laser diffractometry and organic carbon content by the Tiurin method were also determined. The results point to strong human pressure in recent years however a signs of pedoturbations are also quite visible.

Poster no 30

**Simultaneously using Cs-137, Pb-210 and soil properties for the assessment of soil redistribution on an agricultural loess slope**

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Soil erosion and associated sediment accumulation is a serious problem especially on agricultural loess areas. The knowledge about the intensity of soil erosion is important. Quite often to study soil erosion are used radioisotopes Cs-137 and Pb-210. The use of radioisotopes to study soil erosion and sedimentation overcomes many of the limitations associated with the traditional methods.

Unfortunately, this method is related to several problems and limitations. In this work were done detailed study of behavior Cs-137 and Pb-210 on a loess slope used as an agricultural field. The study field is located on the South of Poland near Ujazd village. Simultaneously with isotope measurement an additional geochemical analysis were done as well as: grain size distribution, organic matter, Fe<sub>dith</sub>, Fe<sub>ox</sub>, Al, Mn and pH value.

From a study field were collected 30 soil cores. Beside this 3 soil cores from undisturbed areas as a reference were collected. A sediment cores were sectioned into 10 cm intervals and activities of <sup>137</sup>Cs and <sup>210</sup>Pb<sub>ex</sub> were measured. The results obtained for the study area confirm the potential for using <sup>137</sup>Cs to study medium term soil erosion on agricultural areas. For longer timescale than last 60 years fallout of <sup>210</sup>Pb could be used to study soil erosion. Although <sup>210</sup>Pb is widely used for study lake sediment accumulation, its application to the study of soil erosion is rather small. Detailed geochemical study confirmed that fallout of <sup>137</sup>Cs and <sup>210</sup>Pb is rapidly and strongly adsorbed by clay minerals on the surface of soil and its redistribution on slope could occur in association with mobilized soil particles. The behavior of isotopes should be included into soil erosion calculation. The model of Cs-137 fallout was based on precipitation data was also calculated. To calculate soil erosion a proportional model and mass balance models were used. Financial support of this study throw the funds of the National Science Centre – Poland (Grant DEC-2011/03/D/ST10/05788).



Poster no 31

**The paleoclimate reconstruction based on oxygen and carbon stable isotopes records from flowstones in the Račiška pečina cave (SW Slovenia)**

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Caves work as a natural trap due to the natural isolation of the cave system and cave deposits are often preserved when erosion destroyed surface sediments. Speleothems, one of the chemogenic cave deposits, are valuable tools for palaeoenvironment reconstruction. At the crystallization process speleothems record information about several environmental factors. Basing on analysis of calcite, which is the main component of speleothems, it is possible to get many useful and valuable information on the depositional environment. The variability of oxygen and carbon isotopic composition is particularly often used.

The Račiška pečina cave is located in the south-eastern part of the Matarsko podojlje, a part of the Classical Karst (SW Slovenia). The unique series of flowstones with frequent clay layers in between were deposited in the main cave passage. Based on the paleomagnetic analysis, mammalian zoopaleontology and some numerical datings, it was possible to estimate the beginning of the flowstones deposition as more than 3.4 Ma. The profile contains Pliocene/Pleistocene (at ca 2.58 Ma) transition periods as well as well-developed segment belonging to Olduvai normal magnetic subzone (ca 1.95 to 1.77 Ma) within reversal Matuyama Chron.

Oxygen and carbon stable isotopic composition analyses allow reconstructing main palaeoenvironment changes at the time of flowstone crystallization. The value of  $\delta^{18}\text{O}$  changes within the range of ca 3 ‰ (from -4.27 ‰ to -7.17 ‰). The carbon isotopic composition changes range is wider and reaches 6 ‰ (the  $\delta^{13}\text{C}$  changes from -3.36 ‰ to -11.02 ‰). Obtained isotopic records were correlated with global and regional paleoclimatic data and gain new information on Pliocene/Pleistocene transition climatic conditions in the studied area.

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Poster no 32

**Caves as tools for reconstruction of relief changes in mountain areas – a case study from Tatra Mts.**

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The problem of the Tatra Mts. valleys development is discussed for a long time. Up to date, glacier activity during the Last Glacial Maximum (~20 ka) is supposed to be a major factor determining present mountain valleys morphology and hydrology. However, the initial numerical dating results of speleothems shown that main karst springs were originated earlier than 200 ka and valleys incision in Quaternary was estimated as 80 - 100 m.

Presented research focuses on determining the age of the recent system of karst water circulation in three of main Tatra Mts. valleys: Bystra, Kościeliska and Chochółowska, which is directly related to age of valley incision and morphology. The key to getting the information is study of karst systems located close to the bottom of the valleys or on a small elevation. The caves are kind of "traps" and give a much greater chance of the preservation of sediments (and deposition processes records) during periods of intense denudation at the surface. Close relation between karst forms, karst drainage system, cave morphology and valleys as erosional base makes it possible to study changes in mountain morphology, valleys levels changes, determination of the periods of intensive valley incision etc., basing on karst studies. The evolution of cave system can be reconstructed basing on sedimentological characteristic of cave deposits and their numerical dating. As a major proxy of karst system age, the age of the oldest speleothems in active cave level can be used. Speleothems are autochthonic deposits which are formed under vadose conditions, so the age of oldest speleothems gives estimation of minimum age of cave passage drying caused by erosional base lowering (e.g. creation of a new, lower-lying karst spring).

Intensive studies of caves morphology supported with U-series speleothems dating suggest minimum two stages of karst drainage development. In the older stage, now abandoned caves drained massifs. The direction of paleoflow changed as a result of the water captures depending on valley incision, e.g. drainage of Gąsienicowa Valley by Kasprowa Niżnia Cave to Bystra Valley. The age of active system of big karst springs may be estimated as more than 300 ka (middle Pleistocene). In the later stages, the evolution of cave systems was controlled by glaciation-deglaciation cycles.

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Poster no 33

**Uranium concentrations and initial  $^{234}\text{U}/^{238}\text{U}$  activity ratios in Demänova Cave System (Slovakia) and its significance for U-series dating and paleoclimate reconstructions.**

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Demänova Cave System located in the Low Tatra Mountains (Slovakia) is one of the famous multilevel cave systems of the world. In last years an intensive study of this cave system development was conducted based on Uranium series dating of speleothems. They revealed that Demänova Cave System develops at least from the oldest Pleistocene period, so the oldest stages of system development are beyond range of the U-Th method (older than 500 ka). Theoretically, for older speleothem the suggested age estimator is the  $^{234}\text{U}/^{238}\text{U}$  method according to Regional Uranium Best Estimator method. For this purpose, detailed analyses of Uranium concentration and initial  $^{234}\text{U}/^{238}\text{U}$  activity ratios was carried out. Significant variability of Uranium concentration and initial  $^{234}\text{U}/^{238}\text{U}$  activity ratios have been found as well as correlation between these values. Additionally, both Uranium concentration and initial  $^{234}\text{U}/^{238}\text{U}$  activity ratios are correlated as well with the age of the samples and the location in the cave system. That leads to conclusion that speleothems from different locations in one cave system were formed from different water solutions, which are the source of Uranium in the calcite. Generally, our study proved that the  $^{234}\text{U}/^{238}\text{U}$  method according to Regional Uranium Best Estimator method is not reliable for the caves like Demänova Cave System, it means located in Mountains, with periodic glacial cover and complex geological settings. The most probable reasons are the percolating water path changes and strong changes of sediments distribution and composition above the cave. The detailed study of the characteristic of uranium composition in the Demänova Cave System and vicinity is also important in terms of paleoclimate research. Initial  $^{234}\text{U}/^{238}\text{U}$  activity ratios were used also to infer paleohydrology. In published works the potential use of the  $^{234}\text{U}/^{238}\text{U}$  activities ratio as a proxy of water excess was discussed. Because of the fact that in Demänova Cave System initial  $^{234}\text{U}/^{238}\text{U}$  activities ratio also varies for different age and location in the cave system, its potential use in such complex cave systems as a regional indicator of the amount of rainfall is significantly restrained.

The work was supported by internal project 'Uran' in Institute of Geological Sciences, Polish Academy of Sciences.

Poster no 34

**Timing of active cave passages development and their relation to river terraces – a case study from the Demänová Caves System (Low Tatras Mts., Slovakia)**

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Late Cenozoic evolution of alpidic, including uplift and incision rates, is worldwide deciphering with radiometric dating, and cave deposits utilization is an undoubted contribution here. Simultaneously to valley incision, water tables drop, which in karst areas results in transition of karst conduits from phreatic to vadose zone. This transition reflects in changes both: cave morphology and sedimentary environment. This, in turn, can provide information about landscape evolution, especially in formerly glaciated areas, which usually bear traces only of last glaciation, due to glacial erosion and glacial sediments accumulation. Cave, isolated from external erosion factors, often "stores data" that have already disappeared from the surface. Also in Carpathians – 1,200 km long mountain range – mostly Late Quaternary relief development has been studied and only some singular research of Early Pleistocene has been presented. While Middle Pleistocene is a gap in a history of Carpathian.

Relationship of valley evolution and karstic drainage bases on the concept of cave levels – the concentration of sub-horizontal passages at a certain elevation is connected with some particular geological or geomorphological condition. When valley incision is relatively slow and cave recharge is regular, then passage develops along water table as canyon. When recharge is irregular and epiphreatic zone is well developed, loops, mazes and soutirages have forming.

Noticeably, fluvial incision/aggradation cycle within the cave is similar to river terraces. These relations have been applied in the Demänovská Valley, and described by Droppa in the fundamental work concerning correlation of cave levels with river terraces. He distinguished nine cave levels (later this number was extended to fourteen). Their age is determined on the basis of altitude correlation with terraces of Demianovka stream and Váh river. Levels VIII-IX was described as tertiary and lower as the Pleistocene: I - Würm; II-III - Riss; IV-V - Mindel; VI-VII - Günz. The speleothems dating by U-series method using alpha spectrometry allowed to revise the Droppa's estimation and show that the lowest conduits with active Demianovka stream age is significantly older than would result from the Droppa schema.

This study explores the clastic deposit record with speleothems intercalation, in the Demänovská Cave System, Nízke Tatry Mts., Western Carpathians. In order to decipher incision/aggradation cycles, we combine U-Th dating of speleothems, allows to precise time (age) estimation up to 0.5 – 0.6 Ma, with paleomagnetic relative dating, extending the coverage of our research for older periods. We assumed, that the oldest speleothem give the minimum age of change from phreatic to vadose regime in a specific cave passage and that history of lowering/uplift of base level could be recorded by cave deposits and erosional forms.

The study was supported by project funded by the National Science Centre, Poland (grant no. 2016/21/B/ST10/01483) and by the bilateral mobility cooperation PAN-17-22 and VEGA 1/0146/19.

Poster no 35

**Cob or Kernel: Considerations in the Radiocarbon Dating of Maize**

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Radiocarbon analysis is a powerful tool in the pursuit of absolute chronologies. Researchers routinely encounter limitations that require careful selection of the most ideal materials for such analyses. Certain types of abundant and theoretically ideal materials, including maize, have been maligned due to early disagreements with chronologies established by wood and charcoal. Despite advancements in calibration and normalization, which correct for the fractionation that occurs in the photosynthetic process, misperceptions about maize and its component parts persist. Here we evaluate the competing and apparently unfounded notions that either cobs or kernels consistently and falsely date younger than the associated part through analysis of cob and kernel pairs by accelerator mass spectrometer.

Poster no 36

**Status report from the AMS preparation line in the Gliwice Radiocarbon Laboratory, Poland**

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The Gliwice Radiocarbon Laboratory comprises a unit for preparation of samples for <sup>14</sup>C AMS (Accelerator Mass Spectrometry) since 1999. The system is used to produce graphite from a variety of samples, e.g. plant remains, charcoal, peat, wood, bones, shells, and water.

Conducted research activities include <sup>14</sup>C dating for the purposes of environmental science, Earth science, archaeology, geology and geomorphology, hydrology, reconstruction of past climate changes and human activity, investigation of CO<sub>2</sub> emission from fossil fuel combustion.

The scientific and research equipment comprises chemical preparation stands, vacuum lines for preparation, purification and graphitisation of carbon dioxide. The AMS laboratory was re-installed in 2014 in new premises of the Institute of Physics. Simultaneously, the main upgrade of the laboratory was performed, when the new automated graphitisation equipment AGE-3 was installed. It allowed to increase relevantly the graphitisation throughput from 3 to even 14 graphites per day.

The <sup>14</sup>C concentration in most of the produced graphite in the last four years has been determined in DirectAMS, Bothell, USA. The presentation will summarise the activity of the laboratory, including discussion on the results of blank samples, samples of known age and the standard of modern biosphere.

Poster no 37

**Status of the AMS graphitisation system in the Dendrochronological laboratory at AGH-Kraków**

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A new system for preparation of graphite targets for AMS measurements of radiocarbon concentration has been built in the Dendrochronological Laboratory at AGH-UST Kraków in 2014. This system consists of equipment for mechanical and chemical sample pre-treatment, vacuum line for sample sealing and purification of CO<sub>2</sub>, and graphitization line, where occurs reduction of CO<sub>2</sub> on iron powder. In the first step performance of the system was tested with samples of NIST Ox-II, IAEA standards (IAEA C3, C5, C6, and C8), and blank samples. The test confirms good reproducibility of results obtained for the samples prepared using this system. Now we would like to present the results obtained for all kind of standards, blank samples and repeated samples measured during last 5 years.



Poster no 38

**Searching for abrupt increase of radiocarbon concentration in the past using annual tree rings**

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In year 2012 Miyake et al. as first described a sudden increase of radiocarbon (<sup>14</sup>C) concentration in annual tree rings of Japanese cedar (*Cryptomeria japonica*) and Hinoki cypress (*Chamaecyparis obtusa*) between AD 774 and 775. Shortly after (Miyake et al. 2013 and 2014) another such effect has been described for the period between AD 993 and 994. In both analysed periods, the sudden increase was observed almost in a single year. The increase in the <sup>14</sup>C content was about 12‰ in the period AD 774-775 (Miyake et al. 2012) and about 11.3‰ in the period AD 993-994 (Miyake et al. 2013, 2014). Similar increase was observed in 660 B, with a peak height of about 10‰ (Park et al. 2017). Single-year samples of dendro-chronologically dated tree rings (*Quercus robur*) from Grabie and Kujawy village near Krakow (SE Poland), were collected and their <sup>14</sup>C content was measured using the AMS system. The results clearly show a rapid increase in the <sup>14</sup>C concentration in tree rings between AD 993/994, AD 774/775 and after 660 BC similar to this observed in literature (Miyake et al. 2012, 2013 and 2014, Park et al 2017).

Poster no 39

**Constructing of absolute dendrochronological scale for pine tree from Ujście (NW Poland)**

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Sudden increase of radiocarbon (<sup>14</sup>C) concentration in annual tree rings of Japanese cedar (*Cryptomeria japonica*) and Hinoki cypress (*Chamaecyparis obtusa*) between AD 774 and 775 and between AD 993 and 994 has been described in Miyake et al. 2012, 2013 and 2014. In both analysed periods, the sudden increase was observed almost in a single year. Due to the characteristic of the sharp increase in radiocarbon concentration that occurs in this phenomenon, and due to the global character of this effect, it is possible to use it for accurate dating of annual tree rings, using radiocarbon method. In practice, linking the relative dendrochronological dating and radiocarbon analysis of annual growth rings is possible to use “Wiggle matching” technique to precise determination of the calendar age of samples of pine, from the floating pine chronology (2U\_02A) for central Poland. Absolute dating chronology 2U\_02A covering 227 year, determined on the basis of 50 individual sequences is of great importance for archaeology of the early Middle Ages. This is particularly important for polish history, as during the period covered by this chronology, evolutionary changes occurred, such as the transition from tribal organization to the state organization and the emergence of a series of fortified towns, which dendrochronology dating without pine standard is difficult. So far, summarized standard curves for pine in Poland date back from the present to 1106 AD for Gdańsk Pomerania (Zielski 1997) and 1091 AD for Lesser Poland (Szychowska-Krąpiec 2010) and does not include the Xth century AD.

Poster no 40

**Relationship between stem damage, crown vitality and growth performance of European yew in Central-East Europe**

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As long-lived, slow growing tree species, European yew (*Taxus baccata* L.) has considerable potential for dendrochronological use. In temperate forests of Central-East Europe, its growth is positively affected by higher precipitation during the summer (June–August) and by higher temperature during the winter and early spring (December–March). European yew faces high competition due to the higher stand density accompanied by greater intra-species competition and browsing and bark-stripping by ungulates, which could become a fatal threat to yews. Actually, it is difficult to find healthy looking undamaged trees for possible dendroclimatological studies. The increasing probability of decline and the worsening of yew health status may substantially distort its potential to serve as annually dated climate proxy and for the subsequent precise time series analyses and detection of the dendroclimatic signal. Moreover, cross-sections of yew often showing double pith and poor circuit uniformity are difficult to date absolutely. During 2015–2017 we sampled adult yew populations in limestone beech forests (*Fagetum dealpinum*), in which yew trees exhibit the top growth performance. Altogether, 151 trees were sampled (295 cores) at four localities. Tree-ring series were successfully cross-dated and established basic chronologies and their statistics are presented. Age estimates of sampled trees at coring height range from 70 to 264 years. To remove age-dimensional differences from tree-ring series, we used RCS standardization and explored whether, and to what level, the ring-width indices of the single male and female trees are impacted by the crown vitality status and degree of stem damage caused by bark stripping.

Poster no 41

**Climate signal records in the ring width and stable isotopic composition of Scots pine in Silesia**

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Scots pine (*Pinus sylvestris* L.) is a very useful archive of changes in ecosystems, because it has a specific sensitivity to local environmental conditions, including climate.

In our research the light element stable isotopic composition in Scots pine growing in three industrial regions in Poland (nearby Dąbrowa Górnicza, Kędzierzyn Koźle and Łaziska) was analyzed [1-4].

The carbon and oxygen stable isotope compositions were measured by IRMS (Isoprime, GV Instruments, Manchester, UK) in the Institute of Physics, Silesian University of Technology, Poland.

The climate–radial growth relationships were analyzed for the period 1951–2012, whereas the climate–stable isotopic relationships were analyzed for the period 1975–2012.

To describe the variation of the carbon and oxygen isotope composition of cellulose in annual tree rings of pine caused by climate changes, we used the model based on multiple regression. According to [5,6] under most conditions several factors control variability in  $\delta^{13}\text{C}$ , so correlations with a single climatic parameter are oversimplifications.

In Poland, it is possible to observe that different climatic factors can be linked together, for example: higher number of sunshine hours is linked to higher temperature, also higher total precipitation is linked to higher air humidity during hot summer.

The weather conditions of the current growing season have been reflected in variation of the isotopic ratio. A positive relationship was noted between  $\delta^{13}\text{C}$  and temperature and  $\delta^{13}\text{C}$  and sunshine relationships. A negative relationship has been observed between  $\delta^{13}\text{C}$  and precipitation and  $\delta^{13}\text{C}$  and humidity. Whereas, a positive relationship was noted between  $\delta^{18}\text{O}$  and sunshine and  $\delta^{18}\text{O}$  and temperature, and negative between  $\delta^{18}\text{O}$  and humidity. Climate signal recorded in stable isotope composition was temporally unstable and only for a few of the climatic parameters we found temporally stable climate signals, however the variability in the strength and direction of relationship between variables has been observed. In general, the weather in July and August is important for determining the  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  signals. The instability can reflect the physiological adaptation of the plants to changes in ecosystem.

The authors wish to express their gratitude to everyone who contributed to making these investigations possible. We would like to express thanks to Magdalena Opała from the University of Silesia (Katowice, Poland) for sampling and dating of wood. The research was a part of BIOPOL project “Trees as bioindicators of industrial air pollution during implementation of pro-environmental policy in the Silesia region” – funded by the National Science Centre allocated on the basis of the decision number DEC-2011/03/D/ST10/05251 (PI: B. Sensuła).

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Poster no 42

**$\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$ , radiocarbon, trace metal and Pb isotopic composition in Scots pine needles**

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There have been many analyzes of chemical composition of wood and foliage in the biomonitoring of the ecosystem. In the last few decades, the scientists have studied spatio-temporal distribution of contamination by conducting dendrochemical analyses of different species to establish the impact of soil, air and water pollution. Dendrochemical analysis is based on the assumption that element concentrations in tree represent element availability in the environment in which the tree grows [1-8].

The annual pine needles (*Pinus Sylvestris* L.) investigated were formed in 2012 and collected in winter in 2013. Trace metal Cr, Ni, Cu, Zn and Pb in pine needles record the impact of the pollution emitted by chemical factories, householders and traffic. The variation in isotopic C, O, Pb composition and WUE reflects a mixing between different anthropogenic sources.

The determination of the properties of tree-rings and foliage is crucial for many applications in the investigation of local and global environmental changes. The contamination of the air and rain and soil can be a source of the foliar injury. The monitoring of these metals is important, because some of the elements are essential for life, whereas the others are toxic and can have dangerous impact not only on trees but also on human health. To identify the source of the air contamination, we will be based on elemental composition on the pine needles and on their lead isotopic compositions.

The research was a part of: BIOPOL project "Trees as bioindicators of industrial air pollution during implementation of pro-environmental policy in the Silesia region" – funded by the National Science Centre allocated on the basis of the decision number DEC-2011/03/D/ST10/05251 (PI: B. Sensuła), WBI — bilateral agreements between Poland and Belgium (WBI 2017-2019; PI : B. Sensuła, N. Fagel).

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Poster no 43

**Scanning electron microscopic analysis of trace elements deposition on the pine foliage**

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In the last few decades, the scientists have studied spatio-temporal distribution of contamination by conducting a dendrochemical analysis of different species to establish the impact of soil, air and water pollution [1-2].

The determination of properties of tree-rings and foliage is crucial for many applications in the investigation of local and global environmental changes. The aim of research conducted, within various projects since 2011, in the areas located near different industrial factories in Silesia is to assess the impact of anthropogenic contamination on pine tree stands. Dendrochronological and mass spectrometric studies (using different mass spectrometers such as LA-ICPMS, IR-MS, AMS) allowed to determine the effect of contamination on light element stable isotopic composition (C, O, N) and radiocarbon concentration in annual tree-rings width and foliage of Scots Pine [3-6]. In this article, we present the results the elemental analysis of the young pine needle.

We present the results of the quantitative scanning electron microscopic analysis [7] of pine growing in the industrial forest area in the south part of Poland. Dendrochemical analysis for trace metal pollution is based on the assumption that element concentrations in the tree represent element availability in the environment in which the tree was grown. The samples of the needles collected from conifers investigated in this study covered the time span 2012-2013. The analysis of the elemental composition of pine needles was done using the PhenomWorld ProX scanning electron microscope equipped with an EDS (X-ray energy dispersion spectrometer).

The analysis show the impact of the pollution emitted inter alia by one of the most burdensome factory in this area- Łaziska Power Station and also householders and traffic on the elements concentration in trees. The observed presence of different elements and chemical compounds such as <sup>11</sup>Na, <sup>12</sup>Mg, <sup>13</sup>Al, <sup>14</sup>Si, <sup>15</sup>P, <sup>16</sup>S, <sup>17</sup>Cl, <sup>19</sup>K, <sup>22</sup>Ti, <sup>20</sup>Ca, <sup>26</sup>Fe, <sup>30</sup>Zn, <sup>33</sup>As, on the surface of the needles, has insular character. Most of the elements deposited on the foliage are essential for the functioning of many enzymes, responsible for metabolism, but some of the elements do not play any physiological function, and high concentration can be toxic to the plant [8]. Particulate matter can be harmful also to human life. The plants can be used as a filter, because they can accumulate different contamination on their foliage [9].

To analyze total effect of vegetation in pollutant remediation, variations in dynamic of deposition and precipitation should be taken into account.

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Poster no 44

**Mediaeval traces of mining in the Sowie Mountains (Sudetes, SW Poland) in the light of radiocarbon and dendrochronological dating**

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The origins of mining in the Sowie Mountains reach back to the Middle Ages, when prospecting and exploitation of ore-bearing veins with gold, silver and lead minerals commenced. Traces of historic mining should be looked for in the archives available, as well as in the terrain; e.g. in the form of relics of the old mining facilities. Such studies are not easy, as the elapse of time and turbulent history of the region hinder the search. The archives may provide only fragmentary, residual information, and field exploration is hampered by altered morphology of the terrain. Despite that, quite often the field reconnaissance proved to be successful, as in the case of the several mines presented, of which the entrances were found and interiors penetrated. The studies resulted in the inventory of several old mines, with numerous adits, galleries, and small chambers, from which wood was collected for absolute dating. Samples for dendrochronological and radiocarbon analyses came from:

- Ø mine Marie Agnes (Bystrzyca Górna),
- Ø mine Beata (Bystrzyca Górna)
- Ø mine St. Georg (Modliszów)
- Ø mine Silberloch (Walim)
- Ø adit at Mała Sowa (Walim)
- Ø adits at Błyszcz and Czyżyk Mts (Kamionki and Bielawa)
- Ø mine Teodor (Przygórze)
- Ø adit Osówka
- Ø adit Elisabeth (Srebrna Góra)
- Ø mine New Friedrich

Mining wood is not always available for studies, e.g. in cases of clensing of the rock masses. Sampling under water required help of the divers. Wood for the analyses was taken from wooden casings of chambers, galleries, and sometimes of shafts, as well as from wooden tools (buckets, ladders) and pieces of charcoal. Altogether about 50 samples were taken in the form of slices or cores. The dendrochronological analysis was performed in the Dendrochronological Laboratory of the AGH–UST. The samples mostly represented coniferous species: *Picea abies*, *Abies alba*; only occasionally deciduous ones. Radiocarbon dating was performed in the Absolute Dating Laboratory in Skala. The dates obtained fell in the range from the 15<sup>th</sup> to the 18<sup>th</sup> century. Little wood, however, came from trees cut down in the 15<sup>th</sup> and 17<sup>th</sup> centuries. In the 16<sup>th</sup> century numerous exploration and mining works were resumed in Sudetes, whereas in the 18<sup>th</sup> century development of mining technologies allowed for new investments and expansion of mining activities in the region.

The study revealed only a small part of historic wood preserved in the old, forgotten mines in the Sowie Mountains. During centuries mining facilities were protected with materials available at those times, i.e. mostly wood. Continuation of the research presented should allow to broaden our knowledge on mining objects hitherto unexplored, establish their chronology, as well as enrich and order their history.

Poster no 45

**Dendrochronological dating of St. George's orthodox church in Drohobych**

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St. George's orthodox church of in Drohobych is a wooden monument of sacral architecture, recently enlisted on the UNESCO World Heritage List, among the sixteen orthodox churches in Poland and Ukraine. Although clear, unequivocal written sources about the origins of the structure are lacking, reports on repairs after a tragic fire in 1657 are well known. Some investigators believed that the church was rebuilt that year.

Absolute dating was attempted with the dendrochronological method, due to the rank and value of the object carried out in a non-invasive way. Construction elements of the church were documented with over 40 macrophotographs. The studies were made for selected elements, displaying distinct cross sections (beams) or tangential ones (planks from various parts of the structure). The vast majority of the elements examined represented fir wood. It turned out that the wood used for construction of this orthodox church was contemporaneous and most likely represented a single construction phase. The 124-year chronology based on correlated curves covers the period 1464-1598 AD. Construction elements with the outermost rings retained indicate that the timber was harvested in the 1590s. In most cases the outermost rings were lacking, which allowed only for the dating terminus post quem. However, they all represented a relatively narrow time interval covering the last quarter of the 16<sup>th</sup> century. Distinctly younger wood was encountered in the repaired dome; having come from trees cut down in the years 1819-1821 AD.

The youngest preserved rings (1598 AD) from the orthodox church wood apparently point out both the dates of wood harvesting and the structure construction. Such a dating may indicate, that the orthodox church mentioned in the sources as purchased in Nadiiv in 1657 AD could be the basis for the Drohobych St. George's rebuilding, only adopted to the new conditions. Then the church underwent renovation, consisting in reconstruction of the dome in 1821 AD.

Poster no 46

**Subfossil oaks from riverine sediments of two Latvian rivers: the first results of dendrochronological and radiocarbon analysis.**

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The paper presents the results of initial dendrochronological and radiocarbon analysis performed on subfossil oak trunks embedded in the sediments of meandering Seda and Pededze rivers which make part of the basin of the Gulf of Riga. The rivers have complicated hydrological regime with lateral movements of water channels through the palaeo-beds filled with accumulated sandy deposits and occasional tree remnants. Despite the fact that such subfossil trees are a valuable resource for understanding palaeoenvironmental processes, they have never been investigated. In summer 2018 during a fieldwork 30 samples of subfossil oaks were collected: 19 from Seda (57.780615N; 25.303939E – 57.779093N; 25.281218E) and 11 from Pededze (57.069631N; 26.878676E – 57.070286N; 26.874735E) river banks. Cross-sections of protruding 21 trunks were sampled using a chainsaw but 9 trunks which were inaccessible by sawing were successfully sampled with a Pressler increment borer.

After careful dendrochronological measurement process of sometimes fragmented and broken material the subfossil samples yielded tree ring width series of 47 to 220 years length. Mean length of the series is 121 years. Four groups of relatively dated samples have been identified by cross-matching their tree-ring width series. Only 17 samples have been successfully included into the groups. Mean tree ring width chronologies were calculated for the groups. The chronologies cover 167, 221, 253 and 349 year spans.

Radiocarbon dating of five samples of subfossil oaks was carried out in the Laboratory of Nuclear Geophysics and Radioecology at the Nature Research Centre in Vilnius using liquid scintillation technique. The oldest obtained date was 3090 $\pm$ 45 BP (Vs-2946). The tree ring series of this sample has not been cross-matched with any other sample. Other four dates fall to the first millennium AD: 1745 $\pm$ 36BP (Vs-2898), 1615 $\pm$ 39 BP (Vs-2912), 1415 $\pm$ 45 BP (Vs-2945), and 1340 $\pm$ 50 BP (Vs-2944). Moreover, the latter two dates are of the samples from a relatively cross-dated group with a distance of 164 years between the sampled tree-ring intervals.

The chronology of these youngest samples was absolutely dated to 653 – 1001 AD against the tree-ring chronology of subfossil oaks preserved in Smarhoņ gravel deposits (54.44N; 26.53E) of Neris river upper reaches (t value 5.56, overlap 224 years).

The oldest date within the 1<sup>st</sup> millennium AD (Vs-2898) is of separate, relatively undated sample, but the Vs-2912 date (345-545 calAD, 95.4% probability) positions the group of four samples.

Dating of the subfossil oaks indicates increase in depositional activity of the rivers in the 1<sup>st</sup> millenium AD. Nevertheless, two relatively crossdated groups have not yet been radiocarbon dated. For more detailed reconstruction of palaeo-hydrological processes investigation into larger group of this important source of information is necessary.

Poster no 47

**Battles for the Vilnius Castles at the end of the 14<sup>th</sup> c.: dendrochronological evidence**

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The Castles of Vilnius have been an administrative centre of Lithuanian state since the early 14th c. Intensive archaeological investigation into the site provided a bulk amount of timbers suitable for dendrochronological dating and therefore a medium to understand the site dynamics from the 1260's. The largest cluster of the dates falls to the second half of the 14th century.

Since 1345 for more than three decades Lithuania has been ruled by two brothers of the Gediminids dynasty: monarch Algirdas (Olgiard) with the seat in Vilnius and sub-monarch Kęstutis (Kiejstut) with the seat in Trakai. They successfully defended the state both from the Teutonic Order in the west and the Golden Horde in the east and secured trading routs and cities over the vast territory.

In a military campaign of 1365 the Teutonic Order knights reached and devastated Vilnius environs perhaps for the first time. In February 1377 they already attacked the Vilnius Castles and burned the city. According to differing sources they repeated the attack in the same year. In 1377 Lithuania also faced drastic political changes. In May 1377 monarch Algirdas died. His throne descended to his son Jogaila (Jagiełło) who broke ties with his uncle and started the independent new policy. In 1382 sub-monarch Kęstutis was killed. His son Vytautas (Witold) sought help from the Teutonic Order. The Civil War between loyal groups broke out in which the Teutonic Order actively participated.

In autumn 1383 the Teutonic Order with the supporting troops of Vytautas organised a military campaign to seize Vilnius. In the face of the devastating war Jagiełło made peace with his cousin and in 1384 Vytautas returned from the Order. In 1386 Jagiełło became King of Poland as Władysław II Jagiełło and in 1387 participated in the official Conversion of Lithuania in the Vilnius Castles. Nevertheless, Vytautas did not get the promised position and in 1389 a new phase of the Civil War broke out. In late summer 1390 the Order troops laid siege to the Vilnius Castles. Again, Jagiełło sought peace with Vytautas and in 1392 Vytautas became Jagiełło's regent in Vilnius. The Order did not recognise the Conversion of Lithuania and proceeded with the attacks. In summer 1394 the Vilnius Castles were under siege for 2 months. The last attack took place in 1402.

This perturbed time left rich cultural layer in the Vilnius Castles territory. Dendrochronological investigation of the wooden structures at the Lower Castle site has revealed that many dates of tree felling (and hence building or rebuilding of the structures) are positioned at the last decades of the 14<sup>th</sup> c. Moreover, they correlate with the dates of the events mentioned in historical sources. Planked roads were re-paved in 1377, 1384, 1388, and 1403. Wooden houses, probably destined for military or storage needs or as shelters for citizens, were built and rebuilt in 1377, 1383-1384, 1390-92, and 1394-1395. There are also still unidentified wooden structures which were built in this time.

The paper presents results of dendrochronological dating of the Vilnius Lower Castle structures built at the last decades of the 14th c. which shed more light on the history of this important period.

Poster no 48

**Multi-century long temperature reconstruction based on a multi-proxy dendroclimatological research**

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Dendrochronological method was applied to reconstruct temperature values in the region of Dachstein Mountains (Northern Limestone Alps, Austria). During this study subfossil wood excavated from the Schwarzensee Lake and modern wood originated from trees growing around this lake was used. Separate chronologies were constructed for the ring width, the maximum density of latewood and for the content of stable carbon and oxygen isotopes within individual growth-rings.

These chronologies were compared with climatic record. For this purpose, the temperature data from neighbouring meteorological stations were utilised. Climate-growth relationship was determined by examining the correlation coefficient between measured tree-ring proxies and temperature, in the time interval 1780–2000 CE. Obtained dependencies were statistically significant in the May–September period, for all tree-ring proxies. Linear correlation coefficient computed for this season amounted to 0.471, 0.466, 0.533 and 0.359 for carbon, oxygen, density and ring width chronology, respectively. Therefore, for these months calibration tests were carried out, to establish if the proxies might be combined to provide a more reliable estimate of the common temperature signal. Calculations were performed according to the procedure based on linear regression and proposed by McCarroll et al. (2003). Effective correlation received as a result of this procedure accounted for 0.71 and was significantly higher than the individual coefficients calculated for particular growth-ring parameters.

The temporal stability of the climatic signal was determined on the basis of split period validation tests, taking advantage of linear regression models and using May–September temperature data. Calibration– verification segments covered the periods 1840–1899 CE and 1900–1959 CE. For the calibration and verification periods reduction of error was equal to 0.408 and 0.270, and coefficient of efficiency amounted to 0.408 and 0.269. In turn, correlation coefficient had value of 0.746 and 0.693 and Durbin–Watson statistic amounted to 1.471 and 1.188.

The values of these statistics point that reconstruction skills of chronologies are high. Therefore, for the entire period of 1840–1959 CE a linear regression model was calculated to reconstruct May–September temperature in the time range covered by all Schwarzensee chronologies. Coefficient of determination calculated in regression model showed that the proportion of temperature variance explained by independent variables accounted for 51% in the period common for the growth-ring chronologies and meteorological data.

Performed reconstruction portrays temperature values during May–September months, in years 800–2000 CE. During this time-span the existence of distinct cooling and warming in the area of Schwarzensee Lake was observed. The episodes characterised by an increase in temperature level occurred around the years 1150, 1250, and in the periods 1325–1425, 1625–

1775. The global warming at the end of the twentieth century was also clearly evident. It started in 1925 and intensified since 1975. In turn, the temperature reduction in this area prevailed during the time intervals 900–1100, 1275–1325, 1450–1600 and 1800–1890.

McCarroll D., Jalkanen R., Hicks S., Tuovinen M., Gagen M., Pawellek F., Eckstein D., Schmitt U., Autio J., Heikkinen O. 2003. Multiproxy dendroclimatology: a pilot study in northern Finland. *The Holocene* 13(6) 829–838.

Poster no 49

**Differences in stable carbon ( $\delta^{13}\text{C}$ ) and nitrogen ( $\delta^{15}\text{N}$ ) isotope ratios in bone collagen of modern red deer (*Cervus elaphus*) inhabiting various habitats**

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Red deer is an opportunistic species, which occurs in diverse environmental conditions. One of the methods that allows to indicate habitat and diet of ungulates are analyses of ratios of stable carbon isotopes ( $\delta^{13}\text{C}$ ) and ratios of nitrogen isotopes ( $\delta^{15}\text{N}$ ) contained in bone collagen. Value of  $\delta^{13}\text{C}$  indicates the habitat, in which the animal was foraging (forest or open land), while value of  $\delta^{15}\text{N}$  points out the group of plants, which dominated in diet (woody or soft-tissue vegetation). The aim of our study is to analyse the variability of values of  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  in bone collagen of modern red deer populations occurring in various, well known habitats. Results of such analysis will be used as a reference database for more precise reconstruction of ecology of ungulates living in the past. We studied individuals from 10 populations inhabiting forests (e.g. in the Bieszczady Mountains, the Podlasie Region, the Central Sudetes Mountains in Poland), mixed areas (e.g. the Piotrków Plain, the Volhynia Polesie Region in Poland) and open areas (e.g. the Rhum Island in Scotland and the Flevoland Province in the Netherlands). Samples of bone collagen were isotopically analysed in the Gliwice Mass Spectrometry Laboratory (the Institute of Physics – Centre for Science and Education Silesian University of Technology in Gliwice, Poland) using continuous flow IsoPrime mass spectrometer coupled to EuroVector elemental analyzer. Values of  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  were reported in per mil (‰) relative to VPDB and AIR standards, respectively. Each sample was run in triplicate, with analytical errors of 0.1‰ and for  $\delta^{13}\text{C}$  and 0.2‰ for  $\delta^{15}\text{N}$ . All isotope measurements were made on good quality collagen, as determined by collagen C/N ratios. Our preliminary results showed differences in ratios of carbon stable isotopes in bones of deer living in open habitats ( $\delta^{13}\text{C}$  ranged from -22.02 to -20.69) and in dense forests (from -23.96 to -22.81). We also observed high variability of values of  $\delta^{15}\text{N}$  among deer individuals originating from the same population. The results obtained in this study will be used as the reference data base for results of stable isotopes analysis of subfossil material (red deer bones) and dated with AMS radiocarbon method (obtained in our previous project). This comparison will allow to reconstruct ecological conditions in areas inhabited by the red deer populations in the past.



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