Book of Abstracts

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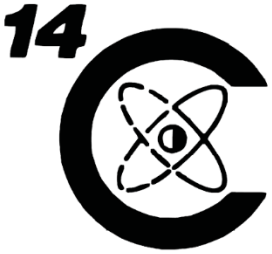

Dear Colleagues,

On behalf of the organizing committee, it is our pleasure to welcome you to the 3rd Radiocarbon in the Environment (RIE) conference, and to your virtual visit in Gliwice, Poland.

During the previous 2nd RIE conference in Debrecen, we could not imagine that due to the COVID-19 outbreak, we will meet in new reality. In order to protect the safety and well-being of all conference participants 3rd RIE conference is a virtual event.

Conference would not be possible without our keynote speakers, sponsors, and many authors who submitted their abstracts. We thank all researchers and students who are working in the fields related to ^{14}C, ecology and environmental change.

We wish to all of you a productive conference, new collaborations and new research exchange opportunities.

On behalf of conference organizing committee,

Andrzej Rakowski

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Abstracts of oral presentations

INVITED

The versatile uses of the ^{14}C bomb peak

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It is well known that two anthropogenic contributions influence the natural $^{14}CO_2$ content in the atmosphere. The emission of ^{14}C-free CO_2 from fossil fuel burning dilutes the ^{14}C content continuously since the industrial age. In contrast, the atmospheric nuclear weapons testing program resulted in a rapid increase of ^{14}C in the late 1950s and early 1960s, which peaked in 1963 when the limited Nuclear Test Ban Treaty ended this program. Since then, the carbon cycle distributed this excess ^{14}C gradually into the biosphere and hydrosphere,. By now (2021) atmospheric $^{14}CO_2$ levels reached almost pre-nuclear levels. This ^{14}C excess is called the '^{14}C bomb peak' and provides a distinct and rapidly changing ^{14}C signal for the past ~60 years. Within this period ^{14}C 'dating' with a time resolution of 1 to 2 years is possible. Since CO_2 emissions from fossil fuel burning will continue - albeit with hopefully decreasing intensity - a substantial depression below the natural level of the atmospheric $^{14}CO_2$ is predicted towards the end of the 21st century [1].

The ^{14}C bomb peak was once colloquially called "The mushroom cloud's silver lining" [2]. This points out a positive side effect of the atmospheric nuclear weapons testing program. The present talk will summarize the use of the ^{14}C bomb peak for investigations in a variety of different fields: (i) The uptake of atmospheric CO_2 into the ocean. (ii) The dating of young speleothems and its importance for recharging groundwater systems. (iii) The study of annual tree ring growth in olive trees (iv) The birth and exchange rate of cells in different parts of the human body. (v) The determination of human death for forensic medicine. (vi) The evaluation of art work with respect to its authenticity. (vii) The preservation of endangered species and its violation by illegal trade. (viii) The question of fraudulant whisky making.

The first four points describe the use of the ^{14}C bomb peak to better understand basic processes in the environment at large. The second four points presents examples which elucidates the dark side of human beings.

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INVITED

Progress in AMS and opportunities for applications in environment research

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The technical evolution of Accelerator Mass Spectrometry (AMS) instrumentation over the years has boosted research with radioactive tracers in global environment. Of course, ^{14}C has been and still is the by far most important AMS nuclide but there is a great potential for applications of other nuclides. Today, 1+ charge state is primarily used in case of ^{14}C detection, molecular interferences are destroyed in multiple collisions with He stripper gas atoms, and a high yield of atomic ions is reached at energies of a few hundred keV, only. Thus, instruments develop towards lab size or table-top devices and performance has improved with respect to overall detection efficiency and reproducibility of measurement conditions. In addition, the advent of hybrid ion source accepting sample materials as CO_2 in a He carrier gas stream [1] enabled the analysis of microgram sized samples making compound specific analyses possible.

The recent technical development will be summarized and examples on specific applications will be discussed to highlight future perspective of research with radiocarbon in environmental research.

The ^{14}C-AMS technology and its applications for evaluation of the properties of highly permeable aquifers cause by large volume water injection in oil field

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The petroleum industry is the backbone of world economy and occupies an irreplaceable strategic position in the international economy and security. At present, the majority of oil fields were in the processes of the secondary or tertiary oil recovery. The full understanding of properties of highly permeable aquifers, such as the thickness, permeability, radius of pore passage, and the remaining oil distribution become an urgent problem to be solved. However, due to their limited sensitivity and the high-level radioactivity, the traditional tracers for the oilfield inter-well monitoring do not work very well. In order to overcome the difficulties of limited tracer species, low sensitivity and the higher radioactivity, and scientifically guide the mining in the mid-late development stage, a technique of ^{14}C isotope tracer combined with highly sensitive accelerator mass spectrometry was developed and applied in the study on the oilfield inter-well monitoring. In this report, the tracer response in production well was tracked, then the advance speed, spread volume and the recovery rate of injection fluid was obtained. Finally, the reservoir heterogeneity characteristics, such as the thickness, porosity, permeability and residual oil saturation, was fitted according to the fluid mechanics theory. The ^{14}C-AMS technique developed in this work is expected to be a standard analytical method for evaluation of the remaining underground reservoir characteristics and provide important scientific guidance and theoretical basis for the mid-late oilfield recovery process.

The IAEA forensics program: results of the AMS ^{14}C intercomparison exercise on contemporary wines and coffees

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In the frame of the IAEA (International Atomic Energy Agency) CRP (Coordinated Research Projects): Enhancing Nuclear Analytical Techniques to Meet the Needs of Forensic Sciences, an intercomparison exercise has been organized and is running between three AMS laboratories. The aim of the program is to promote the use of nuclear and accelerator-based techniques and among them of AMS ^{14}C in routine forensics practice. In this view, one of the key point appears to be the assessment of the precision and accuracy levels achievable on material of forensics interest. Different intercomparison exercises were then organized and run among the three participating facilities: CEDAD (Italy), ETHZ (Switzerland) and Isotoptech-ATOMKI (Hungary) on bones, ivory, material of interest for the cultural heritage (paper, wood and textiles) and foodstuffs. In this paper, we present the general structure and status of the project, with emphasis on results obtained in the analysis of wines of different grape varieties and grounded coffee beans samples from different locations in the world such as Brasil, Spain and Italy. The three laboratories processed the samples according to different chemical protocols and performed the ^{14}C measurements using different systems: MICADAS in Zurich and Debrecen and an AMS HVEE 4130HC 3 MV Tandetron in Lecce. The results showed a good reproducibility, within the quoted uncertainty, of the results obtained by the different laboratories and their consistency with the expected current ^{14}C atmospheric levels, which nowadays have approached pre-bomb values.

^{14}C in biogenic carbonate of plant origin: environmental factors and potential for radiocarbon dating

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Whereas ^{14}C dating of organic carbon of plant remains is one of the most common sources of chronological information in many fields of research, little is known on dating potential of plant carbonate and its radiocarbon levels. Here we investigate the ^{14}C content in fruit carbonate of the tribe Lithospermeae (fam. Boraginaceae), which frequently occurs in sediments and cultural layers of archaeological sites. The influence of atmospheric CO_2 and lithogenic carbon to the ^{14}C balance of fruit carbonate of the taxon were examined during a plant growth experiment with *Buglossoides arvensis*. The plants were cultivated under controlled conditions in climate chambers (with fossil CO_2 influx) and in open air (ambient CO_2) with variable contents of lithogenic carbonate in soils for about 4 months. Our data demonstrate that the ^{14}C levels in fruit $CaCO_3$ of the species under study are predominantly governed by the atmospheric CO_2 without any measurable influence of lithogenic carbonate. Although the radiometric integrity of carbonate in different sediment environments may vary, comparisons of measured ^{14}C ages of old fruit carbonate samples from archaeological sites testify to suitability of plant $CaCO_3$ for ^{14}C dating.

Comparative dating of charcoal, tooth and ceramic samples from the Polutepe archaeological site in Azerbaijan

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The radiocarbon dating method was used to date the age of a charcoal sample from the Polutepe archaeological site in the Jalilabad district of Azerbaijan. Polutepe is the largest Neolithic-Eneolithic monument in the Caucasus. A charcoal sample excavated at the Polutepe site was dated by the conventional radiocarbon method at 4270±160 BC, which agrees with the stratigraphic estimated dates. ESR method has also been applied to determine the age of tooth enamel found in Polutepe archaeological site. The investigated object was presumable the lower jaw of a cow with well-preserved tooth. The mean age of the sample was determined as 5420 ± 130 BC years. The age of fragments of the ancient pottery sample from the same archaeological site has been estimated by employing Thermoluminescence dating method. The age of the sample was calculated by an additive dose method as 4360±530 BC years which are in line with the charcoal samples.

INVITED

Progress towards a PIMS-based laboratory radiocarbon & stable-isotope analysis solution

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Positive ion mass spectrometer (PIMS) has been shown to be competitive with radiocarbon accelerator mass spectrometry (AMS); a powerful plasma ion source sending an ion beam through a hydrocarbon reaction cell is a high-performance alternative to the mature accelerator technique. Essentially ^{14}C-PIMS combines the productivity and analytical precision of solid sample AMS with the convenience and flexibility of gas sample analysis. An academic and commercial venture is seeking to exploit this performance by integrating PIMS into a laboratory technology package capable of radiocarbon and multi-elemental stable-isotope analysis, including sample processing. The project will be described.

Honey as an indicator of long-term environmental changes: MP-AES analysis coupled with ^{14}C-based age determination of Hungarian acacia samples

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Several studies show that the elemental content of honey entirely depends on the botanical and geographical origin, but the information is incomplete regarding time-dependent composition changes. Twenty-six acacia and four honey samples with unknown botanical origin were collected between 1958-2018 and analysed for elemental composition by Microwave Plasma Optical Emission Spectrometry (MP-AES). The elemental analysis was coupled with independent dating method by Accelerator Mass Spectrometry (AMS) to determine the real age of the honey samples and test the possibility of radiocarbon based dating of bee products, which has not been applied before. According to the analytical measurements and statistical analysis, we can conclude that the elemental composition shows change with time in the acacia honey during the last five decades. We have proven that honey preserves information of previous times and thus can be applied as an environmental indicator in reconstruction studies by analysing the non-degradable mineral content. Our results further show that acacia honey is a suitable material for radiocarbon dating, proved by the results compared to the atmospheric radiocarbon bomb-peak. The presented new approach for investigations of honey by radiocarbon-based age determination coupled with elemental analysis can be used in biological, dietary, archaeological or other multidisciplinary studies as well. Some samples show slightly depleted radiocarbon content, based on these results, honey could be used for atmospheric monitoring.

Re-treatment of *Cervus elaphus* bone material in Gliwice Radiocarbon Laboratory using ultrafiltration

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Preparation of bones for radiocarbon dating is still quite a challenge for researchers. The methods are being tested and improved, to obtain better and better results and to verify the previous ones. In this work, a set of collagen samples, extracted in 2018 from *Cervus elaphus* bones and antlers from various sites in Europe, was subjected to re-treatment using ultrafiltration in Gliwice Radiocarbon Laboratory. The samples tested had a wide range of ages, from older than 40 000 ^{14}C years BP to modern. The material prepared in this way was subjected to the measurement of C/N atomic ratios and radiocarbon dating using the AMS technique. Also, the stable isotopes (δ^{13}C and δ^{15}N) values were determined. In this work, we present a compilation of the obtained results.

Stratigraphy of Biśnik Cave: new data and interpretations

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The long sequence of sediments in the Biśnik Cave is a unique situation in Central Europe. In an 8 m thick set of sediments, 20 layers were distinguished. It is also the longest Paleolithic cave site in Poland. After 30 years of first excavations, for this long-term profile in the past were provided series of radiocarbon (14C), optically stimulated luminescence (OSL), thermoluminescence (TL), and Uranium-Thorium (UTh) dates. Among fifteen UTh dates (Hercman and Górka, 2002), those from layers 2, 9, 12, 14, and 15 do not coincide with the dates obtained by other methods (Van Calsteren and Thomas, 2006; Krajcarz et al., 2014). Published TL dates correspond well with the new dating scheme (Cyrek et al., 2009, 2010). The only exceptions are the oldest ones from layers 15 and 19 (Cyrek et al., 2010), which seem to be relatively too old and with high standard deviation (Krajcarz et al., 2014).

Here we present a set of new 32 radiocarbon (^{14}C) dates as well as one new UTh date, which generally confirmed previous data. Seven dates from bats (Chiroptera) and one from the Eurasian brown bear *Ursus arctos arctos* Linnaeus, 1758 documented the Holocene (MIS 1) age of the uppermost sediments (layers 1ab, 1 and 2). Three radiocarbon dates from layer 4 showed very variable results. One gave an age of ca. 14.8-14.3 BP, while another, made from the steppe brown bear *Ursus arctos priscus* (s. l.) was dated on 38.4-37.4 BP. The third was out of the range. Only the second date fits well with five TL dates, presented by Cyrek et al. (2009, 2010). The 13 AMS dates from layers 5-7 are all out of the ^{14}C range. This agrees with previously obtained TL and OSL dates, which gave an age 71-60 kyr (Krajcarz et al., 2014). Similarly, ^{14}C dates from layers 9 and 8 showed values out of range and correspond with those presented by previous authors. The same was with the single UTh date of *Ursus arctos priscus*, which corroborated with data given by Cyrek et al. (2009, 2010).

Different dating methods (^{14}C, UTh, OSL, and TL) confirmed also data obtained from the biostratigraphic analysis. Only the maximum age of the lowermost sediments are still slightly debatable. The whole, exceptionally abundant fauna, confirmed the late Middle Pleistocene age of findings, roughly between MIS 10-1. Among macromammals, ancient species, early Middle Pleistocene faunal markers, are absent. The new re-examination of chronology and fauna shed new light on the history of Biśnik fauna.

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Absolute dating intercomparison one of the biggest necropolis of Lusatian culture at Brzezie in Wielkopolska (Greater Poland)

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Brzezie in the Pleszew region has been mentioned for the first time in the archaeological literature, as a place where a treasure of gold artifacts dating back to the 3rd period of the Bronze Age was discovered in 1876. Archaeological research has been conducted there almost continuously since 1985. The result of many years of fieldwork is the discovery of 363 late Bronze Age (IV – V EB) and Early Iron Age (HaC – D) graves, as well as 50 burials of the Przeworsk culture population.

In the last few years, another research was conducted by Grzegorz Szczurek. After comprehensive geophysical prospection, the extent of the necropolis was established and more graves from the Late Bronze Age and the early Iron Age were excavated.

For the first time, materials for radiocarbon and luminescence dating were also selected to determine the absolute chronology for this archaeological site. Four samples were dated in the Poznań radiocarbon laboratory, and five luminescence results were obtained in the Gliwice luminescence dating laboratory. Due to the complete thermo-destruction of collagen in human bones, age determination was based on carbonate fraction. In one case, a piece of charcoal was selected for dating purposes.

A surprising discrepancy characterizes the obtained results because luminescence results are younger than radiocarbon ones by about 25%. In this work, we would like to discuss the obtained results and possible sources of uncertainty between both methods.

It is very important in this case that dating of artifacts based on typological chains is closer to radiocarbon results.

Radiocarbon age of organic matter in supraglacial systems

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Throughout much of geological history, from the paleoproterozoic onwards, the Earth periodically produced conditions for widespread glaciers, even at low latitudes "Snowball Earth", when there was no higher vegetation and only organo-mineral formations could exist in supra- and periglacial conditions, like what we can observe today. Therefore, they can be considered as modern analogues of biocosic bodies of the distant past. Cognizing them, we approach to the secrets of organic-mineral interactions of ancient epochs. Information about the structure of supraglacial organo-mineral systems is fragmented and unsystematized. It is only know that their set is rather wide - from 1) multicolored organogenic (without mineral fine earth) algal films and products of their decomposition by heterotrophic organisms ("ice soils"), on the one hand, and thin mineral layers (abiogenic?) in polar and alpine glaciers and perennial sea ice, on the other hand, up to 2) cryoconites (accumulations of aeolian and gravitational material on glacier surfaces) enriched with biogenic elements and having a specific structure, and 3) "glacial" soils under developed vegetation up to the forest one on a meter layer of fine soil underlain by the dead ice column (Glacis Cryosols). Data on radiocarbon ages of different components of supraglacial systems are currently sparse and incomprehensible.

The objects of our study are supraglacial systems of the High Arctic (Bertel and Aldegonda glaciers, West Spitsbergen Archipelago, Svalbard), East Antarctica (Schirmacher Oasis, Queen Maud Land), mid-latitude mountain glaciers (Garabashi Glacier, Caucasus). The radiocarbon ages of cryoconites, organic matter accumulated in the body of perennial and annual snowfalls, variegated organogenic films, and soils formed on cryoconite material during rapid glacial retreat have been obtained.

Radiocarbon dating was carried out for total carbon (TOC) as well as for different densitometric and granulometric fractions. The carbon, nitrogen, and isotopic composition of the samples were also determined.

The data obtained for all objects showed that the age of different components of supraglacial systems can vary widely, which is primarily determined by the different sources of organic matter. Three pools of OM can be distinguished: 'fast (pMC>100%) - high rate of OM renewal - it predominantly includes large plant remains included in cryoconite material (predominantly mosses), organo-mineral components from the surface of annual snowdrifts, "transitional" (^{14}C age~100-1000 BP) and "slow" (^{14}C age >1000) - these pools include material from cryoconite holes on glaciers, organic matter accumulated in the body of perennial snowfalls, and OM from soils formed on cryoconite material. The oldest age of OM of supraglacial systems is obtained for heavy densitometric fractions, in which organo-mineral complexes prevail.

Due to its high nutrient content and fine dispersion properties, the material released from melting glaciers can serve as an additional, and sometimes starting, source of nutrients for both soil formation in the Antarctic and the Arctic. An important point is an inclusion in the cycle of the pool of carbon deposited in the body of glaciers for several thousand year.

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Ancient carbon in radiocarbon samples from a glaciated landscape in Minnesota

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The presence of ancient carbon in the environment in certain locations around the world creates confounding issues for understanding human chronology and environmental change through time. Dates on charred food crust or food residues soaked into ceramics are not the only dates under suspicion for being too old in some locations. Radiocarbon dating bones also has come under investigation for certain locations, such as northern Europe, where some radiocarbon dates on human bones have been shown to be non-congruent with either artifacts, historical documents, or both. In the US, animal bone collagen dates are still viewed as the "gold standard" of radiocarbon dating. Although debate has included investigations into whether ultrafiltration or XAD resin purification is better for removing contamination, the premise has been that the carbon in the bone collagen reflects the true age of the animal. The presence of ancient carbon in the environment in certain locations around the world creates confounding issues for understanding human chronology and environmental change through time. Dates on charred food crust or food residues soaked into ceramics are not the only dates under suspicion for being too old in some locations. Radiocarbon dating bones also has come under investigation for certain locations, such as northern Europe, where some radiocarbon dates on human bones have been shown to be non-congruent with either artifacts, historical documents, or both. In the US, animal bone collagen dates are still viewed as the "gold standard" of radiocarbon dating. Although debate has included investigations into whether ultrafiltration or XAD resin purification is better for removing contamination, the premise has been that the carbon in the bone collagen reflects the true age of the animal.

Recent radiocarbon dating curated bones from a rock shelter site in southeastern Minnesota compared dates on bone collagen, charred bone, and calcined bone from the same strata. These dates span a range of nearly 3000 years over the lower five strata and an overlapping range of 800 years in the upper seven strata. In the lower strata dates on calcined bone were generally more recent than dates on either bone collagen or charred bone fragments. The difference in ages between calcined bone and the grouped burned bone and bone collagen was approximately 2000 years, which is no trivial matter. The ages returned for calcined bones were approximately 2000 years more recent than the dates on either bone collagen or burned bones. The dates on calcined bone in the lower strata and all bone in the upper strata span approximately 1000 years, but do not create a trend line with the earliest dates in the lowest strata and the most recent dates in the upper deposits, suggesting a relatively short occupation for this site and/or considerable turbation. Only two bones, one bone collagen date on a duck bone and one calcined bone date, did not yield dates that conform to this pattern.

As a control, fish caught in 1939 (the year of the excavation) and stored in paper bags to create a bone reference set for use in identifying fish bones recovered from the site were curated as part of the same archaeological site collection. They yielded dates varying from 307 to 1250 years BP. Walleye pike, a high trophic level fish, yielded the most recent date, while catfish (bottom feeders) with a low trophic level yielded the oldest date, indicating that ancient carbon was introduced to the diet of these fish (and, thus, their collagen) from their aquatic environment. We explore the relationship between the glaciated and unglaciated Minnesota landscape and radiocarbon dates from these bones and a few aquatic plants.

INVITED

Applications of bomb radiocarbon in environmental and climate studies

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Bomb radiocarbon is a powerful dating tool for the post-1955 period as it can deliver dating accuracies of one to a few years for recent terrestrial samples. Bomb radiocarbon has been employed in various research disciplines including forensic studies, biomedical and ecological research, and soil carbon studies. In this paper, we focus on the applications of bomb radiocarbon in environmental and climate research through the illustration of several case studies. In these studies, we have used bomb radiocarbon together with stable isotopes ($\delta^{13}C$ and $\delta^{18}O$) and elemental abundances for research on threatened pasacana (*Echinopsis atacamensis*) cacti from the Bolivian Altiplano, and tropical mangroves (*Avicennia marina)* and sub-tropical, semi-arid gidgee (*Acacia cambagei*) trees containing no identifiable annual growth rings. We have constructed reliable chronologies for Bolivian pasacana cacti through radiocarbon dating of cactus spines used to determine their growth rates. The dating, together with stable isotopes, will improve the management and conservation of this threatened species and demonstrates the potential use of the cactus as a climate archive. We have also dated *A. marina* mangroves in northern Australia to investigate causal mechanisms for a massive mangrove dieback event, which occurred in 2015-2016 along ca.1000 km of pristine coastline in the Gulf of Carpentaria. In addition, elemental abundances (Sr and Ca) and bomb radiocarbon have been employed to accurately date gidgee trees in a semi-arid area in south western Queensland, Australia. The constructed chronologies enable correlation of alpha-cellulose $\delta^{18}O$ to local climate records, suggesting the climate reconstruction potential of gidgee trees for semi-arid regions of Australia.

Latitudinal distribution of atmospheric $\Delta^{14}CO_2$ over the Southern Ocean

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The Southern Ocean is a key sink for anthropogenic carbon dioxide (CO_2), yet the processes that govern the rate of uptake remain only partly understood. We use observations of $\Delta^{14}C$ in CO_2 from shipboard transects across the Southern Ocean to develop latitudinal gradients of $\Delta^{14}C$ in the surface atmosphere. We present five years of austral summer observations (2016-2020) from ships of opportunity travelling between New Zealand and the Ross Sea, Antarctica, along with long-term measurements from Baring Head, New Zealand and Arrival Heights, Antarctica. We observe lower $\Delta^{14}C$ in the 50°S to 70°S region, with higher values to the north and south, consistent with upwelling of ^{14}C-depleted deep waters in this region. We then combine model ocean simulations of CO_2 and ^{14}C with simulations from the NAME III atmospheric dispersion model to predict surface atmosphere $\Delta^{14}C$ and compare with the observations. Our model simulation does a reasonable job of matching the observations, capturing the spatial pattern and day-to-day variability quite well. However, the model somewhat underestimates the magnitude of the observed $\Delta^{14}C$ gradient, particularly between 50°S-60°S. Our results suggest that atmospheric ^{14}C observations can be used to diagnose the strength of deep water upwelling in the Southern Ocean.

Wheat seed (*Triticum aestivum* L.) radiocarbon concentration over the last 75 years

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Here we report radiocarbon measurements made on wheat seed tissue (*Triticum aestivum* L.; winter or spring type growth habit), collected from the seed storage archive of the IPK Gatersleben, Sachsen-Anhalt, Germany, between the years 1946-2020. The results give an overview about 75 years radiocarbon concentration evolution in agricultural plant products.

The wheat tissue radiocarbon concentrations follow known pre- and post-bomb radiocarbon records such as the atmospheric Jungfraujoch, Schauinsland, and NH1 datasets (e.g. Hammer and Levin, 2017a; Hua et al, 2013; Levin and Kromer, 2004). Considering a growth period between April and July, the seed tissue radiocarbon concentration indicates incorporation of fossil carbon at about 1% with respect to the high alpine, clean-air CO_2 of the Jungfraujoch station between 1987-2015.

The youngest (2018-2020) measured wheat tissue radiocarbon concentrations vary around -1.4‰ (2018) and 1.3‰ (2020).

We propose to use the pre- and post-bomb radiocarbon record of Gatersleben wheat as a reference in forensic investigations such as the age estimation of paper by analyzing starch, used in paper manufacture. Additionally, an advantage of the record reported here lies in its extensibility by adding new analyses from future harvests.

Radiocarbon measurement of precipitated atmospheric samples from 1960-1980

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The radiocarbon laboratory in Trondheim started collecting atmospheric C-14 samples in 1962 when Reidar Nydal established a network of 14 sea level stations from Kapp Linné, Spitsbergen, in the North to Madagascar in the southern hemisphere where atmospheric CO_2 was absorbed in dishes with a sodium hydroxide solution. The samples were precipitated as $CaCO_3$ with $CaCl_2$ in Trondheim. While many of these samples were measured, there is still a large archive of samples that have not been measured and could be used to document the global bomb spike in more detail.

The samples have now been stored at the laboratory for a few decades, which could have caused contamination by atmospheric CO_2. Since the samples were intended for measurement by gas proportional counters, they are large enough for several AMS measurements and decontamination experiments. Using previously measured archived samples and coal backgrounds, we investigated potential contamination and the possibility for re-measuring the old samples with a higher precision than could be done back in the 1970s, and extend the dataset with the previously untreated ones. We used two different methods of CO_2 production; 'combustion' in an elemental analyzer and hydrolyzation in phosphoric acid. Different cleaning methods were tested such as hydrogen peroxide leaching in addition to CO_2 production without pre-cleaning the samples. The results of the different methods generally match well, but some deviations from the original measurements were observed where about 60 % of the new results are within 2 σ of the original measurements. The specifics of the deviations and our attempts to reduce them will be discussed.

Development of a new system for sampling atmospheric methane for radiocarbon analysis

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Methane (CH_4) is the second most important anthropogenic greenhouse gas, and observations have shown a dramatic increase in concentration over the past ten years (Nisbet et al. 2019). The contribution to this rapid growth remains poorly understood, and attributing methane emissions to specific source-sectors is critical for a better understanding of the methane budget. Radiocarbon is one of the most powerful tracers for distinguishing fossil from biogenic sources on global and regional scales (Lassey et al. 2007; Graven et al. 2019). Fossil methane has lost all its ^{14}C over millions of year of radioactive decay and, when emitted to the atmosphere, causes a dilution of the atmospheric $^{14}C/C$ ratio that can be quantified. Despite their usefulness, presently there are few published measurements (Lassey et al. 2007; Townsend-Small et al. 2012). This is mainly due to challenges in the sampling procedure.

In this study we present the development of a unique sampling system for $^{14}CH_4$ analysis that enables efficient collection of enough carbon for high precision $\Delta^{14}C$ measurement (0.15-0.3 mgC) by using molecular sieves. Our sampling procedure separates the methane carbon from air during sampling, reducing the need for sample processing at the radiocarbon laboratory and associated costs. In this system, collection of a CH_4 sample is made by catalytically combusting CH_4 into CO_2 during the sampling, and adsorbing the combustion-derived CO_2 into a 13X molecular sieve trap.

Here we discuss the first radiocarbon measurements in atmospheric methane in central London, showing the efficiency of this sampling technique and how it can be implemented at different sampling locations.

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Optimised aerosol fraction separation in arctic aerosol for radiocarbon measurement

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The Arctic is a challenging environment with a smaller input of local sources and a significant influence by long range atmospheric transport owing to its remote location. Much attention is paid to carbonaceous aerosols in the Arctic due to their influence on climate, however, most research concentrates on elemental carbon (EC) and very little on organic carbon (OC). Some attempts have been made to utilize organic tracer compounds for source apportionment. Source apportionment using radiocarbon is a powerful technique, which allows for separation of fossil and non-fossil sources of carbonaceous aerosols. Radiocarbon analysis on filters sampled in the Arctic is demanding due to low filter loadings. We have developed an optimised technique for the measurement of the Fraction Modern of total carbon (TC), EC, and water-soluble organic carbon (WSOC) on aerosol filter samples based on radiocarbon measurements, using accelerator mass spectrometry (AMS).

For an optimal separation of OC and EC, filters were water extracted before removal of water-insoluble OC (WINSOC), using thermal-optical analysis (Zhang et al., 2012). Water extraction lowers charring in the thermo-optical Analyzer and thereby improves the OC/EC separation. In the present work, the eluate from the water extraction was collected, acidified, and purged with helium for carbonate removal. The remaining organic carbon was directly converted to CO_2 by chemical wet oxidation before radiocarbon measurement in an AMS (Lang et al., 2016). Zhang et al. (2014) collected and lyophilised the eluate from the water extraction. Then, the samples were re-solubilised and transferred in tin boats or quartz vessels for oxidation to CO_2 and AMS measurement using an Elemental Analyzer or a Sunset OC-EC Analyzer, respectively. Direct WSOC oxidation and measurement utilising chemical wet oxidation simplifies the procedure and obtain lower blanks by omitting eluate freeze-drying and re-solubilisation steps.

We applied the described method to filter samples collected at the Zeppelin Observatory, Svalbard, in 2017-2018. Fossil sources dominated in all aerosol fractions (TC, EC, WSOC) in winter. In summer, TC and WSOC originated predominantly from biogenic sources. For the EC measurements in summer, there was no precedence for neither fossil nor non-fossil.

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DID ATOMSPHERIC FOSSIL CARBON RATIO DECREASE IN THE CHARPATIAN BASIN DUE TO THE COVID-19?

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COVID-19 has a significant effect on the community and the economy worldwide. It is a question if some environmental risk and pollution sources had reduced impact due to the reduced industrial and transport activity in 2020. Atmospheric CO_2 level rise and its fossil carbon load/ratio is one of the most important environmental issues nowadays. The natural, cosmogenic radiocarbon (C-14) gives an unique scientific tool for quantification of the fossil origin atmospheric carbon load, as fossil sources has no C-14 activity, while recent biogenic carbon has. In this study, we have investigated the last 7 years period, including 2020 and present the long-term trend of atmospheric C-14 level. Results of the trend analysis in the atmospheric fossil carbon load will be presented for the year of COVID-19, relative to the previous 6 years. Monthly integrated atmospheric CO_2 samples, and tree-rings from the last 7 years were C-14 analysed from 2 different locations: an urban environment (Debrecen) and a background atmospheric station (Hegyhatsal) in Hungary. The research was supported by the European Union and the State of Hungary, co-financed by the European Regional Development Fund in the projects of GINOP-2.3.2-15-2016-00009 'ICER'.

Radiocarbon on urban secondary carbonate deposits: site effect and implication for chronology of historical pollution reconstruction. Case study of Paris and Versailles Palace's fountains

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Secondary carbonate deposits similar to speleothems from caves were sampled in Paris (France) and neighbourhood, in historical aqueducts north and south of the town, in a former underground quarry under a wood and in a gallery under a fountain of Versailles Palace.

We use the atmospheric radiocarbon bomb pulse recorded and compare it to uranium thorium dating and / or laminae counting, to constrain the chronology of these deposits. We determine a growing period between the last decades to the last century. By comparing ^{14}C atmospheric record to ^{14}C carbonate record, we determine the dead carbon proportion for each sample. For the studied sites, in similar climatic context and for part of them, similar geological context, we observed a large range of dead carbon proportion, from a few percent to ca 40 %. We discuss this variation according to sites characteristics, water origin and pathway. Without surprise, secondary carbonate deposits fed by water with rapid transfer through very thin soil (fountain of the Versailles Palace) has the lowest dead carbon proportion. The highest values are found for carbonate deposits of the former underground quarry under the wood. Intermediate values are from samples fed by the waters of northern and southern perched aquifer drained by the historical aqueducts. We then link this parameter to the record of temporal inorganic pollution by these secondary carbonates.

The effect of the Haifa Bay power station on the adjacent dune aquifer

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Seasonal variations were observed in dissolved inorganic carbon (DIC) of groundwater in the dune aquifer along Haifa Bay. The $^{14}C_{DIC}$ decreases in winter compared to summer and the $\delta^{13}C_{DIC}$ values become enriched. The sediments of this sandy aquifer were laid during a higher sea- level stand approximately 4000 years ago and include old sea shells. The changes were observed in wells near a power station which emits ~15,000 tons of SO_3 annually. Winter rains dissolve the SO_3 deposited on the ground during the dry summers. The acid formed partially dissolves the sea shells in the dune sands, which joins the DIC. This result in the variation observed in the DIC in $^{14}C_{DIC}$ and in $\delta^{13}C_{DIC}$. Towards summer, the added rain partly dilutes the effect of the shells on the groundwater. The dissolution of shells is further confirmed by the Ca^{2+} data in the wells.

Preoperational levels of radiocarbon in the vicinity of the European Spallation Source (ESS), Lund, Sweden

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The European Spallation Source (ESS) is a neutron-based research facility under construction in Lund in Scania, southern Sweden. The neutrons will be produced by bombardment of a target of tungsten with a proton ion beam of high energy (up to 2 GeV) and power (up to 5 MW). The resulting spallation reactions will not only generate the desired neutrons, but also many radioactive by-products, including ^{14}C. ESS is not classified as a nuclear facility, but is treated as such in the licensing process. As part of this process, and as recommended by the IAEA, various preoperational studies must be carried out, including mapping the baseline ("zero-point") radiation environment around the site. As the city of Lund hosts several facilities using ^{14}C-labelled substances, and since temporary and local ^{14}C-contamination has been observed in the past, ^{14}C is an important part of these baseline assessments. We present a summary of ^{14}C levels in various terrestrial environmental samples, such as trees, grass, fruits, berries, milk and meat in Lund and in southern Sweden from the years 2012 to 2020. We also describe a local ^{14}C contamination event that occurred in Lund in 2008-2009: analysis of horse-chestnut *Aesculus hippocastanum* leaves displayed $F^{14}C$ values of up to 25% above clean air background. The $F^{14}C$ in a short series of tree rings also showed elevated values, especially in 2008. The potential source of this contamination is discussed. The environmental $F^{14}C$ data from Lund for the period 2012-2020 do not display significantly elevated levels compared to sites located remote from Lund.

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Tracking nuclear and fossil fuel CO_2 in southern Ontario (Canada) using radiocarbon on tree-ring and atmospheric samples

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In Southern Ontario, Canada there are 18 operational CANDU reactors at three nuclear power plants (Bruce (8), Darlington (4) and Pickering (6)). Southern Ontario is also one of the most densely populated regions of Canada and is a major source of fossil fuel derived carbon that is depleted in 14C. Monitoring of atmospheric ^{14}C began in 2008 by Environment and Climate Change Canada (ECCC) at Egbert, Ontario, 70 km north of Toronto, and at the downtown Toronto ECCC site in 2010. While the Egbert site provides a clean air reference and the Toronto site is subject to strong fossil fuel emissions, one must consider the magnitude and spatial distribution of the nuclear ^{14}C emission as it will mask the modern biological and fossil fuel CO2 signatures in Southern Ontario's atmosphere.

Here we measured the $\Delta^{14}C$ in tree rings from white spruce (Picea glauca) trees sampled across a west-east geographic transect between the NPPs (including the city of Toronto) with the aim of better understanding how the atmospheric concentration of ^{14}C has varied locally in this region, while also attempting to pinpoint sources of ^{14}C emissions. The tree-ring ^{14}C measurements at the Egbert clean air site agree well with the atmospheric measurements, and from 2002-2017, the tree-ring data tracks globally derived 14C data from the Jungfraujoch clean-air atmospheric sampling site in Switzerland. At the Toronto site, the tree-ring ^{14}C measurements (2010-2017) are markedly more depleted than the atmospheric samples likely due to the height of sampling and proximity to a major road. At the site nearest to Pickering ("ROS", 20 km downwind), the tree-ring ^{14}C signature for the years 2009-2017 is enriched up to 60‰ above JFJ and the fluctuations correlate with reported ^{14}C emissions data from Pickering (r=0.88 and adjR2 =0.76). The long-term trend at the ROS site, going back to 1994, shows enrichments relative to JFJ up to 400‰ corresponding to major refurbishment periods of the various reactors at Pickering. The same "events" are recorded in the Egbert site long-term trend, going back to 1993, showing enrichments relative to JFJ up to 10‰. This final observation confirms that the reach of the $^{14}CO_2$ from the Pickering Nuclear station is up to 75 km against the prevailing wind direction and therefore must be taken into consideration when interpreting the $^{14}CO_2$ measurements in downtown Toronto and the wider region.

Application of the carbonaceous fraction of particulate matter and natural carbon isotopes for emission source apportionment in Krakow (Poland)

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Krakow is the second largest city in the country with the population of almost 1 million inhabitants. The Krakow City Council decided about a total ban on combustion of solid fuels starting from September 1, 2019. However, Krakow is still affected by car exhaust emission. The city's geographic location – inside the valley surrounded by hilly terrain where smaller towns and villages are located, induces temperature inversion and influx of polluted air masses from the neighbouring areas. We report here the results of analyses of air particulate matter samples from one-year campaign conducted in Krakow (Poland) from May 2018 to April 2019.

Apart of concentration of PM_1 and PM_{10} fractions, the measurements comprised chemical analyses of carbonaceous fraction (organic and elemental carbon, selected carbohydrates) complemented by isotope analyses ($^{13}C/^{12}C$ and $^{14}C/^{12}C$ ratios) of the total carbon (TC) reservoir. The results show the large difference between annual average concentration of PM_1 (26.94 ug/m^3) and PM_{10} (67.73 ug/m^3). The PM_{10} concentration ranged from 11.0 to 145.0 ug/m^3, whereas PM_1 values were between 6.1 and 62.6 ug/m^3. The highest concentrations of PM_1 and PM_{10} were measured during winter and the lowest during summer months. The average values of fossil fuel fraction (FF) in Krakow derived from the measured radiocarbon content of TC reservoir also depend on the season of the year. During the six warm months (May 2018 – August 2018, March 2019 – April 1019) average FF value for PM_1 and PM_{10} was noticeably lower (avg. 42.6%) than during 6 colder months (September 2018 – February 2019) (47.19% and 54.41% for PM_1 and PM_{10}, respectively). Higher FF results for autumn-winter months accompanied by reduced radiocarbon content in PM_{10} compared to PM_1 fraction points to substantial presence of ground-level emission sources of carbonaceous aerosols (burning of coal for household heating purposes). The annual average $\delta^{13}C$ values were practically the same for both fractions (-24.7‰). Concentration of Levoglucosan (well-known biomass marker) was analysed using HPAE-PAD Dionex ICS 3000. Its concentrations during 6 warmer months were in the order of 0.1 ug/m^3, to be compared with 0.3 ug/m^3 in winter (PM_1) and 0.2 vs. 0.65 ug/m^3 for PM_{10}, which leads to the conclusion that in colder months of 2018-2019, wood-burning for heating purposes still took place in Krakow. The obtained carbon isotope data will be used to make source apportionment of carbonaceous fraction using the isotope mass balance approach.

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Biomonitoring of the industrial area: air pollutants accumulation in the pine foliage – a case study

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Trees are an archive of environmental changes. The impact of pollutants on the forest's condition in the industrial region in Silesia, has been a subject of many discussions and studies in which various research methods are used. The results of the research can be used in bio-monitoring of the environment on a local, regional and global scale. Since 2011, research that has been conducted at the Institute of Physics-CND of the Silesian University of Technology, allow for a comprehensive analysis of the impact of climate change and industrial air pollution on the width of annual tree increments and changes in the isotopic and elemental composition in trees: annual shoots and pine (*Pinus Sylvestris* L.) wood in the last century. The analysis made in last decade shown a high concentration of 14C in Silesia (higher concentration than in the "clean" air). We present the results of the analysis of elemental and isotopic analysis of pine needles. The samples were collected from pine, which have been growing in close proximity to the roads in Silesia. The geochemical analysis of the samples was made with using different methods (AMS- Accelerator Mass Spectrometry - radiocarbon analysis, IRMS-Isotope Ratio Mass Spectrometry-stable isotopes analysis, Inductively Coupled Plasma Atomic Emission Spectroscopy - ICP AES- elemental analysis, respectively). We present temporal and spatial variations of carbon isotopes ($\delta^{13}C$ and ^{14}C) and elemental composition of the needles.

The research was a part of the Project Based Learning: "Applied Physics and ArcGIS technology in the Environmental Research: Air pollutants accumulation in the foliage - a case study of biomonitoring of the industrial area (ACCUM)" (PI: Barbara Sensuła, Team Leader: Dawid Lazaj)

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INVITED

The forest hides treasures: Developing atmospheric post-AD 1950 high-precision ^{14}C records using cellulose material from absolute calendar-dated tree rings across the Neotropical region

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Currently, atmospheric post-AD 1950 ^{14}C records are missing from sites across the western portion of the Southern Hemisphere, and especially at lower latitudes over the tropical low-pressure belt (previously called the Inter-Tropical Convergence Zone; Hua et al., 2013). To better constrain the annual and interannual dynamics of atmospheric circulation and its effects on aboveground ^{14}C distribution, we are evaluating and producing ^{14}C gradients of tree species/sites over the Neotropical region. Recently produced atmospheric post-AD 1950 ^{14}C signatures for the Altiplano based on tree rings of *Polylepis Tarapacana* were modeled for their backtracking air-mass parcels (Ancapichún et al., 2021). As such, it was found that the Altiplano atmospheric $\Delta^{14}C$ record is primarily sensitive to changes in air parcels' geographical provenances and their associated carbon reservoir fingerprints, rather than being modulated by the El Niño-Southern Oscillation (ENSO) and/or northeastern air parcels that originate solely from the Amazon Basin. This is important, as it contradicts the assumption that all geographical provenances across the pantropical region should show the same atmospheric post-AD 1950 ^{14}C fluctuations: i.e., a single annual value covering a large geographic grid across this zonal division (about 60°) between the Northern and Southern Hemispheres (Graven et al., 2017). To elucidate regional exchange and circulation patterns of ^{14}C across the Neotropical region, several ^{14}C tree-ring records are being produced. An atmospheric post-AD 1950 high-precision ^{14}C record for the Eastern Amazon Basin based on single tree rings of *Cedrela Odorata* from 1940 to 2016 has been screened (Santos et al., 2020) and now has been fully reconstructed. Moreover, new tree species are being evaluated for their annuality in order to validate studies associated with precipitation variabilities and paleoclimate reconstructions. These studies are pressing and timely, especially at the Amazon Basin, where observational climate data is at best scarce and mostly nonexistent. We expect that newly-to-be-developed tree-ring ^{14}C records at lower latitudes along a west-east gradient would ameliorate important deficiencies of the current ^{14}C atmospheric CaliBomb global map (Hua et al., 2013; Santos et al., 2020) and shed some light on the impacts of climate variability in the tropics.

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INVITED

Search for past SEP events using tree-ring ^{14}C data

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Cosmogenic nuclides are good proxy for searching for past solar energetic particle (SEP) events. So far, three events (775 CE, 993 CE, and ~660 BCE) were confirmed by multi-nuclides data, i.e., ^{14}C in tree rings (e.g., Miyake et al. 2012; 2013, Park et al. 2017) and ^{10}Be and ^{36}Cl in ice cores (e.g., Miyake et al. 2015, Mekhaldi et al. 2015, O'Hare et al. 2019), and it's considered that the origin of these events is an extreme SEP events. Recent studies using ^{14}C analyses have reported more candidates of candidates of extreme SEP events (e.g., Brehm et al. 2021). In order to search for other signatures of extreme SEP events, We have searched for SEP-driven ^{14}C variations in tree rings, i.e., annual rapid increase and the following decrease. Here, we will show the current status of the SEP event survey, and discuss a newly discovered candidate of an extreme SEP event in 5410 BCE.

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Isotopic Evidence in Support of Grand Solar Minimum around 2300 cal BP

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Variations in solar activity determine the total insolation of the Earth, and thus make an important contribution to palaeoclimate models. All reconstructions of solar activity, prior to the age of instrumental observation, rely on proxy data from natural archives. Two of the most important proxies are the isotopes ^{14}C, preserved in dendrochronological sequences, and ^{10}Be, trapped in ice cores. Several recent studies have shown that single-year isotope series are particularly valuable for assigning observed trends to specific causes. One such trend is the rise and fall in atmospheric $\Delta^{14}C$ values that accompany Grand Solar Minima (GSM). GSM are episodes lasting from a few decades to more than a century in which the Sun appears unusually quiescent. The most recent GSM can be substantiated by sunspot records, and several earlier minima are tentatively linked with the Little Ice Age. However, other dynamics of the Earth system can result in similar perturbations of the atmospheric $\Delta^{14}C$ record. In this study, we present more than 50 new ^{14}C measurements over the rise and fall observed around 2300 cal BP, a far greater density of dates than currently underlies this portion of the calibration curve. By comparing the new results with both known GSM, and patterns usually attributed to environmental processes, we conclude that our data most likely support the occurrence of a GSM.

Modelling the contribution of carbon sources in sub-annual ^{14}C measurements on tree rings over the 1963 bomb spike

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Measurements of the radiocarbon content of sub-annual wood cellulose samples over the 1963 bomb spike have revealed a delay between the increase in atmospheric radiocarbon content and that of wood cellulose. This delay is apparent in both coniferous and deciduous tree species and is of a magnitude of approximately 5-6 weeks. The delay in wood cellulose change as measured in a Sitka spruce (*Picea sitchensis* (Bong.) Carr.) from Washington state, USA, was used by Grootes et al. (1989) to estimate the relative influence of tree physiological effects contra environmental effects. The results indicated that the effects of delayed incorporation of carbon into the wood cellulose and the effect of stored photosynthate were small compared to the contribution from biospheric CO_2 from decomposing plant material. Here, we repeat the measurements of that same Sitka spruce with the increased measurement precision of today's AMS systems. We compare these new results with the ones of a Scots Pine tree (*Pinus sylvestris* L.) from Trondheim, central Norway. This allows for more detailed modelling of effects like stored photosynthate, biospheric CO_2, tree species dependence and local influences such as canopy cover or ocean upwelling.

Tree–rings as archives of atmospheric pollution by fossil carbon dioxide: Bratislava case

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Radiocarbon analysis of annual growth rings of trees is an excellent tool for investigation of past radiocarbon levels in the environment. Since the industrial revolution, human activities have been influencing atmospheric radiocarbon levels, either by input of ^{14}C-free fossil carbon dioxide into the atmosphere (Suess effect) or by production and release of additional radiocarbon by nuclear technologies (atmospheric tests of nuclear weapons, nuclear reprocessing facilities, nuclear reactors). Because of the process of photosynthesis, these anthropogenic changes of ^{14}C in the atmosphere are transferred into the biosphere as well. Tree-rings retain the carbon isotopic information from the time of their creation, and radiocarbon analysis allows us to acquire this information.

We will present results of radiocarbon analysis of a tree-ring series from the city of Bratislava in Slovakia covering the period from 1970 to 2004. For a part of this time period, monthly radiocarbon measurements of atmospheric carbon dioxide from Bratislava sampling station (heavily polluted by fossil CO_2) are also available and will be compared with the tree-ring results. The effects of fossil carbon dioxide emissions on radiocarbon levels in the environment are emphasized by comparison with atmospheric $^{14}CO_2$ data from Schauinsland clean air sampling station in Germany. The presented results from Bratislava will also be set against the previously measured tree-ring series from Low Tatras mountain region in Slovakia, representing regional clean air radiocarbon levels in the biosphere. The observed radiocarbon levels of Bratislava tree rings and atmospheric CO_2 in 1970s and 1980s are significantly lower than both the atmospheric and biospheric clean air data, reflecting intense fossil CO_2 pollution in Bratislava during this time period.

INVITED

^{14}C "Bomb peak" and the onset of the Anthropocene

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During the last 200 years the pristine pool of cosmogenic ^{14}C in the atmosphere and connected reservoirs (biosphere, ocean, soils etc.,) has been perturbed by human activities. However, it was only during the last century that the unprecedented environmental changes resulting from anthropogenic activities initiated during the Great Acceleration of the mid-20th century took place (Syvitski et al. 2020). In the early 1950s, the decreasing trend observed in ^{14}C concentration of the atmosphere (Suess effect) has been temporarily reversed by thermonuclear tests of the 1950/60s, which created an excess of artificially produced ^{14}C (Bomb pulse). This time marker of the mid-20th century is a useful tool in numerous applications in environmental, biomedical and forensic studies. Recently, the detection of the bomb peak in natural archives has also been proposed as a tool to locate and date the onset of a new epoch the Anthropocene (Zalasiewicz et al., 2015). The Anthropocene Working Group (AWG) supervises research of stratigraphic successions at 11 sites around the globe in order to facilitate a formal submission to the Subcommission on Quaternary Stratigraphy. This paper will present an introduction to the Anthropocene and an overview of the role the ^{14}C bomb peak and its onset plays in the research dedicated to establishing the Global Boundary Stratotype Section and Point (GSSP) for the proposed Anthropocene.

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Air quality assessment based on aerosols deposited on bio-passive sampler (Abies alba needles)

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In this study we tested *Abies alba* needles as a possible bio-passive aerosol sampler. Needles can be useful tool for air pollution monitoring as they are covered with specific natural wax, which facilitates the retention of particles on their surface. What is more, this method can be representative year round, as the many of conifers do not lose their leaves in winter. Twenty different localizations within the Holy Cross National Park (Poland) were chosen and *Abies alba* needles were collected there in 2013. Aerosols were washed from the surface of the needles using distilled water and then analysed for $\delta^{13}C$. The carbon isotopic analyses were also carried out for needles themselves. Additionally, analyses of total carbon, elemental carbon and organic carbon in aerosols trapped on needles surface were carried out. The idea was that differences between $\delta^{13}C_{needle}$ and $\delta^{13}C_{aerosols}$ caused by enriched aerosol in ^{13}C due to fossil fuel use, allow us to indicate an anthropogenic impact on the air quality. Enrichment in ^{13}C in aerosols was observed in locations that are: a) in the vicinity of inhabited areas, b) highly elevated c) situated outside the park. Samples with the longest exposure time revealed the highest concentration of aerosols, while the lowest mass concentrations were noted in the samples with the shortest exposure. We proved that the most useful are one-year old needles and their comparison with needles exposed on polluted air only during growing season.

Biosensors in ^{14}C contaminated environment: tree rings research and lake sediments analysis

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It is well know that naturally radiocarbon originates in upper atmosphere layers caused by cosmic radiation initiated *n,p* reaction with nitrogen. But in certain areas radiocarbon activity in bio samples may be increased by local Nuclear Power Plant (NPP) exploitation. Tree rings analysis is the most useful method to analyse longterm radiocarbon emission impact on environment, because they almost all the year rapidly correspond to ^{14}C isotopical change in atmospheric environment. Tree rings and undisturbed lake sediments ^{14}C activity measurements can provide an undistorted data of chronology. This information could be used to reconstruct events of elevated radiocarbon releases and different stages (electricity production, maintenance, decommissioning) of nuclear power plant exploitation.

In this research we analysed more than 400 tree ring samples from vicinity of Ignalina NPP and 24 layers of Drūkšiai lake bottom sediments core. Pine tree rings were collected from 8 locations and lake sediments core was taken in the deepest lake point. Radiocarbon measurements were completed with preparation equipment AGE3 and measurement equipment - Single Stage Accelerator Mass Spectrometer (produced by NEC) (Skog et al. 2009, Wacker et al. 2010).

All these measurements revealed increase of ^{14}C background by up to 17 pMC in local site atmosphere and up to 94 pMC in alkali soluble fraction of organics in bottom sediments layer corresponding to 2000. Impact of Ignalina NPP is clearly observable in many biomaterials. Due to different origins of sample material and complexity of analysed processes this research demonstrates and expands radiocarbon measurement usage for environment analysis.

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Radiocarbon bomb-peak signal in tree-rings from the tropical Andes register low latitude atmospheric dynamics in the Southern Hemisphere

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South American tropical climate is strongly related to the tropical low-pressure belt associated with the South American monsoon system. Despite its central societal role as a modulating agent of rainfall in tropical South America, its long-term dynamical variability is still poorly understood. Here we combine a new (and world's highest) tree-ring radiocarbon record from the Altiplano plateau in the central Andes with other radiocarbon records from the Southern Hemisphere during the second half of the 20th century in order to elucidate the latitudinal gradients associated with the dissemination of the bomb radiocarbon signal. Our tree-ring radiocarbon record faithfully captured the bomb signal of the 1960's with an excellent match to atmospheric radiocarbon measured in New Zealand but with significant differences with a recent record from Southeast Brazil located at almost equal latitude. These results imply that the spreading of the bomb signal throughout the Southern Hemisphere was a complex process that depended on atmospheric dynamics and surface topography generating reversals on the expected north-south gradient certain years. We applied air-parcel modelling based on climate data to disentangle their different geographical provenances and their preformed (reservoir affected) radiocarbon content. We found that air parcel trajectories arriving at the Altiplano during the bomb period were sourced i) from the boundary layer in contact with the Pacific Ocean (41%), ii) from the upper troposphere (air above the boundary layer, with no contact with oceanic or continental carbon reservoirs) (38%) and iii) from the Amazon basin (21%). Based on these results we estimated the $\Delta^{14}C$ endmember values for the different carbon reservoirs affecting our record which suggest that the Amazon basin biospheric radiocarbon isoflux could have been reversed from negative to positive as early as the beginning of the 1970's. This would imply a much faster carbon turnover rate in the Amazon than previously modelled.

Temporal incoherence of SN1054 signal in ^{14}C series from various tree-ring archives

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Keywords: ^{14}C, tree rings, SN1054, dynamic time warping

The annual rate of ^{14}C production in the lower stratosphere-upper troposphere reflects the changes in cosmic-ray flux over time due to changes in galactic cosmic rays and solar energetic particles, and solar-geomagnetic shielding. A signal of rapid changes in ^{14}C production rate is logged in annual series of ^{14}C from tree rings and associated with a diverse range of cosmic-ray flux effects including solar burst and supernova events. As of now, three solar energetic particle events (SEP 774 CE, 993 CE, and 660 BCE) and one supernova (SN1056) have been confirmed with the annual ^{14}C series from multiple locations and AMS faculties. Five other proposed events (1279 CE, 813 BCE, 1528 BCE, 5480 BCE, and 5410 BCE) need to be corroborated with data from multiple locations. It is known that manifestations of the same astronomical event in carbon-14 may occur with a time lag and variations in intensity across different parts of Earth (e.g. see the meridional decline of 11-year mean atmospheric ^{14}C concentrations across both hemispheres in Büntgen et al. 2018).

Investigation of the effect of the Crab Nebula supernova (SN1054) on the annual rate of ^{14}C production found a ^{14}Cexcursion at 1054/55 CE of 4‰ at two locations (Terrrasi et al 2020). However, other studies report a lower or higher magnitude of this event and/or different year of the effect – 1052 CE (Dee et al. 2016, Eastoe et al. 2019, Brehm et al. 2021). We investigate the temporal coherence of the published ^{14}C series for SN1054 from four tree-ring archives at three locations (Finland, California, and England) using a novel technique of dynamic time warping. Dynamic time warping (DTW) is an algorithm for measuring similarity between time series where oscillations may vary in speed. The method allows stretching or compressing sub-sections of the time axis at different time scales under certain statistical constraints in order to minimize the possible dissimilarity between the compared time series (Izakian et al. 2015).

DTW analysis determined that ^{14}C variance amplification at both 1052 CE or 1055CE is caused by the impact of a single event. The inconsistent fingerprint of SN1054 event in time across space may result from cross-dating nonconformity, regional (local) flux of old carbon at the northern location due to intensified permafrost melt and CO_2 release at the Medieval Warm Epoch, large volcanic eruptions in Utah and Nicaragua between 1050 CE and 1060 CE and/or large latitude gradient. The γ-ray shock from supernova explosion disturbs the chemistry of the atmosphere with possibly multifaceted forcing, although its signature in ^{14}C annual variations is obscure. Clearly, the SN-signal of abnormal ^{14}C production rates differs from the highly coherent SEP (solar proton radiation)-signal in delta ^{14}C. It should be noted that these variations in the ^{14}C production rate increase cannot be explained by the Schwabe cycle alone

(Terrasi et al. 2020, Brehm et al 2021). P. Damon's upper limit of 6‰ ^{14}C for a large SN event at similar distances as the Crab Nebula (Damon et al. 1995) should be revised now as the precision of AMS ^{14}C measurements is significantly improved and the background concentration has changed. Attribution of SN signal in annual ^{14}C series needs further investigation with larger spatial datasets.

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Dee at al. 2016

Eastoe et al. 2019

Izakian et al. 2015

Terrasi et al. 2020

INVITED

Evidence for solar-flare, supernovae and other cosmic-ray events in the 14C record in tree rings

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Various ^{14}C excursions apparently caused by an increase of incoming cosmic rays on a short time scale found in the Late Holocene have generated widespread interest and have been reproduced in many different tree-ring records (Miyake et al. 2012, 2013, 2017; Büntgen et al. 2018). These changes are normally expressed in terms of Delta^{14}C. These rapid excursions at AD 774-775 (see Büntgen et al. 2018 for a detailed summary) and AD 993-994 are well-documented but with an increasing number of studies using annual ^{14}C analysis, more detail is being revealed (Miyake et al. 2013; Güttler et al. 2015; Fogtmann-Schulz, 2017). A third rapid increase event at 660BC (Park et al. 2017; O'Hare et al. 2019; Sakurai et al. 2020) likely also due to extreme solar proton events (SPE). New SPE-like events have been reported at 5410BC (Miyake et al. 2021), 1279AD and 1052AD (Brehm et al. 2021), increasing the probability of such events. Terrasi et al. (2020) proposed that an event at 1055AD, which would overlap with the 1052AD event, was of supernova origin, However, there are also other types of change in ^{14}C production, that may be due to a mix of SPE and different phenomena, such as around 5480BC (Miyake et al. 2017) and 5410BC (Miyake et al. 2021) in bristlecone pine and 815BC in sequoia records (Jull et al. 2018). The change at 5480BC is proposed by Miyake et al. (2017) to be a combination of the onset of a solar minimum and SPE events. Similarly, the increase of D^{14}C around 815BC may be related to the beginning of a solar minimum at about the time of the 800-400BC plateau in radiocarbon ages, which is coeval with the period of the Iron Age in European archaeology. A diverse range of processes has the potential to affect cosmic-ray flux, including solar events, gamma-ray bursts, geomagnetic shifts and supernova (e.g. Usoskin et al. 2013). A proposed event about 3372-3371BC (Wang et al. 2017) was also attributed to SPE effects, although the timing of the event is based on a floating chronology and is not yet confirmed (Jull et al. 2021). Uusitalo et al. (2018) noted a small latitudinal dependence in ^{14}C from the 774AD event, but these effects were just small differences in amplitude, not displacement of the timing. Recently, Park et al. (2020) noted a small regional difference in timing from a tree from Korea, as opposed to other reports.

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INVITED

Compound specific, flow cytometry-based-pollen, and other radiocarbon environmental researches using a Single Stage Accelerator Mass Spectrometry at the Atmosphere and Ocean Research Institute, The University of Tokyo

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The NEC 250kV single-stage AMS (YS-AMS) was installed in March 2013 at the Laboratory for Accelerator Mass Spectrometry (LAMS), Atmosphere and Ocean Research Institute, The University of Tokyo. It is the first single-stage

AMS system installed in Japan. The system is equipped with a 40 solid sample ion source (MC-SNICS-II), sequential injection system at low energy mass spectrometry side, open air 250kV high energy deck including helium gas stripper which acts as a molecular dissociation, analyzing magnet, electrostatic analyzer, sequential post-accelerator deflector, and final detector. Our routine 14C measurements were started from August 2013, and have been keeping a high operational availability. During this period, the cumulated accelerator operation time is over 58300 hours. We have performed more than 630 runs and acquired data more than 13,000 samples. In this presentation, we will introduce ranges of scientific studies using the YS-AMS system in the fields of earth science, paleoenvironmental science, marine science to fisheries science. Flow cytometry-based high efficiency pollen purification system as well as compound specific radiocarbon dating enable us to detect precise signatures of environmental changes that will be also introduced in the talk.

AMS ^{14}C dating, C/N and $\delta^{13}C$ of plant species from peat mires: Something we should know for paleorecord reconstructions

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Peat cores are important achieves for paleoclimate and paleoenvironmental reconstructions especially in highland and high latitude areas. Many previous studies have used bulk peat samples for AMS ^{14}C dating and stable isotope analysis for paleo-reconstructions. However, there are many plant species in peat including different Sphagnum, moss, herb and woody species. This study presents measurement results of AMS ^{14}C, N%, C%, $d^{13}C$ on plant species in two mires, Hani and Jinchuan Mires, located in Northeast China. A total of 18 species of modern plants were collected from Hani Mire in 2018 ($F^{14}C_{atm}$ 1.04±0.004). The mean values with standard deviation of $F^{14}C$, N%, C%, C/N and $d^{13}C$ (‰ VPDB) are 1.0159±0.0082, 0.90±0.10, 44.39±1.41, 49.5±4.5, -27.20±0.58 for mosses (5 species); 1.0104±0.0141, 2.06±0.88, 47.85±2.95, 25.7±8.5, -21.18±5.26 for herbs (5 species); and 1.0082±0.0092, 2.52±0.98, 53.34±2.10, 25.0±12, -25.79±4.91 for woods (8 species), respectively. Some species such as *Carex angustior Mac.*, *Drosera rotundifolia Linn.* and *Potentilla fruticosa L.* contain significantly low $F^{14}C$ (ca. 0.995) and should be excluded in dating. Higher than expected $F^{14}C$ values (>$F^{14}C_{atm}$) appeared in many species, perhaps indicating those species uptake CO_2 from the water depth where the post nuclear bomb ^{14}C was high. While the standard deviation of $d^{13}C$ values for mosses is relatively small, the herbs and woods have large standard deviations, implying that using $d^{13}C$ record of peat cores must consider mixture of plant species. Different plant species were collected from a peat core, JCB retrieved from Jinchuan Mire in 2018, at 0-1cm and 35-36 cm depths. The average value with standard deviation of $F^{14}C$ for 9 dating species at the top layer is 1.0453±0.0705, whereas the average $F^{14}C$ value for 6 dating species at 35-36 cm layer is 0.9544±0.0171 (equivalent a ^{14}C age of 376±145 yr BP). The dating results indicate that *Carex* seed, Carex rhizome, *Cyperaceae* root and *Ericacese* branch are not good for dating due to mobility, uptake dissolved CO_2, and perhaps drafting layer during coring.

Problems of constructing the Late Pleistocene radiocarbon chronology of natural events in tectonically active mountain terrains (by the example of the Russian Altai)

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The Altai Mountains (mountains of southern Siberia) are one of the tectonically active mountain provinces of the Central Asia collision belt. The most ancient and highly mountainous southeastern part of Russian Altai (SE Altai), presented in this study, is characterized by a complex tectonic and sedimentation history. As a result of tectonic movements, Tertiary organic bearing lacustrine and boggy deposits in the region have been partly uplifted and exhumed on the ridge's slopes. During the Pleistocene these deposits were affected by various exogenous processes including glacial and glacio-fluvial activity, winnowing activity of ice-dammed lakes, sliding as a result of outburst flood events, followed by further intensive Holocene erosion, pedogenesis and permafrost formation/degradation. Within the region there are also areas of even more ancient (Late Paleozoic (Middle and Upper Carboniferous) and Mesozoic (Lower Jurassic)) deposits, which are associated with fault boundaries between intermountain depressions and framing ridges. After exhumation these deposits were affected by the same exogenous processes.
Such a complicated sedimentation history predetermined the presence of a source of ancient organic matter in the region. The influence of further geomorphic and pedogenesis processes would strongly affect the results of radiocarbon dating, which is currently one of the most useful and widely applicable technique available for conducting geochronological reconstructions. Due to the redeposition of ancient organic material and the high probability of mixing organic matter of different ages, understanding of genesis and composition of dated organic material is necessary for the correct interpretation of obtained numerical results. Multidisciplinary studies give opportunities to reveal any possibilities of contamination of dated substances with young or old carbon and avoid any misinterpretation of their ^{14}C ages.
An extremely critical factor can be contamination of old organic matter by "young" carbon. It is well known that the admixture of only 1% of modern carbon to an indefinitely ancient sample (e.g. with true age of 100 ka BP) would give a final apparent date of about 37 ka BP. In contrast, the erosion and redeposition of ancient sediments into younger Pleistocene or Holocene deposits resulted in an overestimation of their ^{14}C ages, although the effect of such aging is much less significant.
Within tectonically active mountain terrains, including Russian Altai, both processes could be observed. This paper presents the results from multidisciplinary investigations of pedosedimentary sequences, analyzes the specific examples of rejuvenation and aging radiocarbon dates, and discussion on the problems of the Late Pleistocene-Holocene ^{14}C chronological reconstruction of natural events in tectonically active mountain terranes.

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

January air palaeotemperature for 28-21 cal. ka BP based on stable isotope composition of AMS radiocarbon dated syngenetic ice wedges at Seyakha site, Yamal Peninsula

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The main aims of the study are ^{14}C dating of syngenetic ice wedges and enclosing sediments, obtaining the data of stable oxygen and hydrogen composition of ice for high-resolution isotope diagrams from detailed sampled yedoma exposed in third lagoon-marine terrace near the mouth of the Seyakha (Zelyonaya) River, on the coast of the Ob Bay, Yamal Peninsula (70°9'26.51"N, 72°34'8.76"E).

Seyakha syngenetic ice wedges were ^{14}C dated with conventional liquid scintillation counting (for enclosing sediments) and by AMS dating (organic micro-inclusions extracted directly from ice wedges).

Radiocarbon age measurements. AMS radiocarbon dating was carried out in the Laboratory of Radiocarbon Dating and Electron Microscopy of the Institute of Geography of the Russian Academy of Sciences (obtaining counting material) and the Center for Isotope Research of the University of Georgia in the USA (direct measurement on an accelerator mass spectrometer). ^{14}C ages of 3 bulk samples were obtained in the Institute for the History of Material Culture, St. Petersburg.

Stable isotope measurements. The isotope composition of oxygen and hydrogen in the ice were made in the mode of constant helium flux (CF-IRMS) on a Delta-V mass spectrometer using a gas-bench complex, at the isotope laboratory of the Geography Department, Lomonosov Moscow State University (MSU).

Chronostratigraphy. For organic micro-inclusions, extracted from ice wedges, 4 AMS ^{14}C dates in the range from 28 to 21 cal ka BP were obtained (Table1). For the enclosing sediments 3 dates in the range from 29 to 27 cal ka BP were obtained (Table 2).

Stable isotope ratio. Ice wedges from 2 sections on Seyakha outcrop were sampled for stable oxygen ($\delta^{18}O$) and hydrogen ($\delta^{2}H$) isotopes. In the upper ice wedge, two vertical trends for $\delta^{18}O$ values can be distinguished: from +12 to +14.2 m $\delta^{18}O$ values vary in the range of about 1.5‰ - from -24.18 to -25.75‰, from +14.2 to +15.8 m there is a clear upward positive trend of $\delta^{18}O$ values of 2.6‰ from -25.75 to -23.15 ‰.

The range of $\delta^{18}O$ values along the horizontal line at the height of +15.2 m is 1.49‰ - from -23.41 to -24.9‰. The lower fragment of the ice wedge, exposed at +6 m, is characterized by a wider range of values of $\delta^{18}O$ than in the upper fragment: $\delta^{18}O$ values along the horizontal line vary from –23.41 to –26.63‰.

Previously obtained isotope-oxygen diagram for ice wedges from Seyakha yedoma [Vasil'chuk et al., 2000] has a step of 800 years, and new isotope data allowed to obtain the diagram with a step of 80-100 years. This suggests that the new high-resolution isotope-palaeotemperature record almost has no gaps and covers a period of 5-8 thousand years from 28 to 21 cal ka BP.

Table 1. Radiocarbon dates of TOC (organic micro-inclusions, extracted from ice wedges) samples from the Laboratory of Radiocarbon Dating and Electron Microscopy of the Institute of Geography of the Russian Academy of Sciences and the Center for Isotope Research of the University of Georgia (USA)

Sample ID	Height, m asl	^{14}C, BP (1σ)	Lab ID	from cal BP	to cal BP	Median cal BP
YuV-16S/52	+15.2	17680±50	IGAN$_{AMS}$-7335	21800	21015	21399
YuV-16S/12	+12.1	21755±55	IGAN$_{AMS}$-7338	26347	25829	25969
YuV-16S/62	+6.0	24495±80	IGAN$_{AMS}$-6907	29120	28405	28755
YuV-16S/69	+6.0	25281±80	IGAN$_{AMS}$-6908	29958	29185	29551

Table 2. Dating of allochthonous peat horizons from the Seyakha yedoma exposure

Sample ID	Height, m asl	^{14}C, BP	Lab ID	from cal BP	to cal BP	Median cal BP
YuV-16S/ 76	+5.0	23300 ± 640	Le-11406	29865	25902	27596
YuV-16S/ 77	+3.0	24100 ± 300	Le-11407	29205	27425	28292
YuV-16S/ 78	+2.0	25200 ± 420	Le-11408	30923	28083	29497

New stable isotope data suggest that from 28 to 21 cal ka BP the mean January air temperature, reconstructed according to the equation from [Vasil'chuk, 1991], ranged from -35 to -39°C (recent mean January air temperature is -23°C). A marked upward increase of oxygen isotope values in the ice wedge is most likely due to the increase of mean air January temperature at the final stages of the ice wedge growth.

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The first radiocarbon dated leopard Panthera pardus (Linnaeus, 1758) from the Pleistocene of Poland

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As a newcomer of African origin, the leopard appeared in Europe 1.2-1.1 Myr, with the oldest record from Vallonnet Cave (Moullé, 1992; Michel et al., 2017). O'Regan (2002) highlighted that the arrival of the leopard in Europe might have placed pressure on *P. gombaszoegensis*. *P. pardus* would have focused upon smaller animals, which were at the lower end of the jaguar prey size range. An unanswered question is why, despite its enormous environmental and hunting adaptability, the occurrence of *P. pardus* in the Middle Pleistocene is limited to a few sites (von Koenigswald et al., 2006). However, at the same time, the leopard was widespread in Africa and Asia (Geraads, 2008; Geraads et al., 2010). It was present in Europe until the end of the Late Pleistocene, even during the very cold and continental climatic phase after the glacial maximum (Spassov and Raychev, 1997). O'Regan and Turner (2004) described the Middle Pleistocene *P. pardus* as a relatively small cat of gracile posture and narrow teeth. The small size of the early leopard may have been a response to reduce the competition with other large carnivores (maybe mostly with the jaguar), in the areas where these two species coexisted (Hemmer, 2001, 2004; García and Virgós, 2007). Recent leopard is not a top predator throughout most of its range, and the situation during the Pleistocene was most probably the same. Leopards are adapted to living alongside with other large, sympatric predators, such as lion, tiger, wolf, or hyena. Their shy behaviour, avoiding areas frequented by larger predators, taking smaller prey and hunting at different times of day/night, taking their kill high up a tree may reduce the competition (Nowell and Jackson, 1996). Being intermediate in size between the lion and leopard, *P. gombaszoegensis* occupied a fairly isolated ecological niche aiming exactly to lower the pressure of competition. After the jaguar disappeared, *P. pardus* spread widely in Europe, increasing in size and substituting ecologically *P. gombaszoegensis* (García and Virgós, 2007). The number of late Middle Pleistocene localities with leopard remains, younger than 300 kyr, considerably increased (Sauqué and Cuenca-Bescós, 2013; Diedrich, 2013). The leopard reached the maximum extension of its geographical range in the Late Pleistocene. The spread of *P. pardus* was accompanied by a trend of size increase, whereby the initially relatively small and gracile leopard became larger and more massive. The size of the largest Late Pleistocene specimens was comparable to that of small Middle Pleistocene jaguar, and they held the ecological niche occupied so far by *P. gombaszoegensis* (Hemmer, 2004; García and Virgós, 2007). The signs of such interactions were also found on the bones of Polish leopards. A broad query showed the leopard's presence on 121 European sites, which covered the timespan of the last ca. 1.2 Myr. Among them are 5 Polish cave sites located on the territory of Silesia (southern Poland). All records came from rocky regions with rugged terrain convenient for ambushes and hiding. The leopard preferred such habitats during the Late Pleistocene to avoid competition with other, large carnivores. Among the most important

was the cave wolf *Canis lupus spelaeus* Goldfuss, 1823, in which numerous packs overwhelmed Silesian lowlands. For the first time, the leopard from Radochowska Cave was also dated on the second half of MIS 3.

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High-resolution stable isotope records reflect January air paleotemperature of 49-22 ka cal BP in Central Yakutia (applying AMS radiocarbon dated of Ice Wedges of the Batagay Yedoma)

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Batagay megaslump exposed the greatest geocryological formation known in the world in the north of Central Yakutia in the upper reaches of Yana River (67°34'49''N, 134°46'19''E). A vertical wall of 70 to 100 m exposes the yedoma with thick syngenetic ice wedges, underlying by older horizontally layered frozen sediments with narrow ice wedges. This outcrop began to be studied relatively recently but some interesting results have been obtained [Murton et al., 2017; Vasil'chuk et al., 2017, 2019; Ashastina et al., 2017; Opel et al., 2019 et al.]. To study the paleochronology and paleoclimate of the Batagay area, complex studies including radiocarbon dating (as well as AMC dating of micro-organic inclusions in ice wedges) and stable isotope studies were carried out by authors.

Radiocarbon age measurements. AMS radiocarbon dating was carried out in the Laboratory of Radiocarbon Dating and Electronic microscopy of the Institute of Geography of the Russian Academy of Sciences (obtaining counting material) and the Center for Isotope Research of the University of Georgia in the USA (direct measurement on an accelerator mass spectrometer).

Stable isotope measurements. The isotope composition of oxygen and hydrogen in the ice were made in the mode of constant helium flux (CF-IRMS) on a Delta-V mass spectrometer using a gas-bench complex, at the isotope laboratory of the Geography Department, Lomonosov Moscow State University (MSU). The calibration was made with OxCal software [Bronk Ramsey, 2009] using IntCal 20.

Stable isotope and air temperature relationship. To establish the $\delta^{18}O$ and air temperature relationship we compared winter and January air temperature and the $\delta^{18}O$ values of modern ice wedges (or veinlets) in different regions of the Eurasian permafrost area [Vasil'chuk, 1991]. These relationships are expressed in the following simplified regression equations: $t_{mJ} = 1.5\delta^{18}O_{iw}$ (± 3°C) where t_{mJ} - mean January air temperature; $\delta^{18}O_{iw}$ is oxygen isotope composition of ice-wedge ice.

Detailed isotope-oxygen and deuterium diagrams obtained from ice wedges [Vasil'chuk et al., 2020], allowed to suggest the very severe winter conditions prevailed in the Verkhoyansk region of Central Yakutia in the Late Pleistocene. The chronological reference of these diagrams was based on the dating of the yedoma sediments. But presence of reworking organic material in the yedoma that lead to aging of radiocarbon dates is a rule [Vasil'chuk, Vasil'chuk, 2017], so several ^{14}C age inversions are also found among the dates obtained from micro-inclusions of organic matter from the Batagay sediments.

Chronostratigraphy. The three ice wedges profiles (IW-3, IW-5 and IW-7) were sampled to cover the entire exposed permafrost and ice wedge sequence at in spatial context. 7 AMS ^{14}C dates from 34396 to 27156 cal BP were obtained from micro-inclusions of organic matter extracted from IW-3. However, not all dates can be considered as a valid. Using the previously developed strategy for selecting valid dates in yedoma [Vasil'chuk, Vasil'chuk, 2017], the most reliable dates are 27156 cal BP from a depth of 6.7 m and 30886 cal BP from a depth of 10 m.

Thus, one can calculate the rate of vertical growth of ice wedge IW3: 3.3 m of ice accumulated in about 3.7 ka, i.e. the rate of accumulation was about 1 m per 1 ka years. Consequently, the fragment of IW3 with vertical thickness of 5.5 m was accumulated over a period of about 5 ka - from 30.9 to 25.9 cal ka BP.3 AMS ^{14}C dates in the range from 49232 to 44724 cal BP were obtained from micro-inclusions of organic matter extracted from IW-5. However, the sample dated to 49232 cal BP from a depth of 14.8 m is most likely contaminated with ancient organic matter, so the more reliable dates are 47541 cal BP from a depth of 17 m and 44724 cal BP from a depth of 12.55 m. Thus, the rate of vertical accumulation of IW5 ice wedge was about 1.3 m per 1 ka years. Consequently, the studied fragment of IW5 with vertical thickness near to 8 m accumulated over a period of about 6 ka - from 47.5 to 41.5 cal ka BP.

3 AMS ^{14}C dates in the range from 52.2 to 45.8 ka cal BP were obtained from micro inclusions of organic matter extracted from IW-7. However, the uppermost sample from a depth of 2.4 m, dated to 52286 cal BP, is most likely contaminated with ancient organic matter, so the more reliable dates are 45844 cal BP from a depth of 7 m and 47908 cal BP from a depth of 12.8 m. Thus, the rate of vertical accumulation of ice IW7 is quite high and exceeded 2.5 m per 1 ka years. Consequently, the studied fragment of IW7 with vertical thickness of about 12 m accumulated over a period of about 5 ka - from 47.9 to 42.9 cal ka BP.

The overlap in sampling positions of the three profiles (Fig. 1, 2) and the modelled age-height relation allows for deducing a stacked record that differentiates into three chronostratigraphic and ice wedge units:

IW-3: MIS 2, Yedoma IC (27.1 to 30.8 cal ka BP), IW-5: MIS 3, Yedoma IC (44.7 to 47.5 cal ka BP), IW-7: MIS 3, Yedoma IC (45.8 to 47.9 cal ka BP).

Stable isotope ratio. Ice wedges from three sections on Batagay outcrop were sampled for stable oxygen ($\delta^{18}O$) and hydrogen ($\delta^{2}H$) isotopes; the first section (IW-3) was located in the left wall at the mouth of a ravine, the second section (IW-5) and the third section (IW-7) in the southwestern part of the Batagay megaslump. Ice screws were used to drill transects across the exposed ice, keeping a distance of 0.1-0.2 m between the drill-holes.

Table. The range and mean values of $\delta^{18}O$ and $\delta^{2}H$ in the ice wedges from Batagay yedoma

Number of samples	$\delta^{18}O$, ‰			$\delta^{2}H$, ‰		
	Min	Mean	Max	Min	Mean	Max
IW3.Depth 5-10 m (315-320 m asl.)						
38	-34.83	-34.36	-32.47	-272.6	-266.3	-255.6
IW5. Depth 9-17 m (273.9-266 m asl.)						
53	-35.15	-34.12	-32.36	-273.5	-264.5	-238.1
IW7. Depth 1-12.8 m (239-227.2 m asl.)						
79	-35.36	-34.33	-32.98	-276.0	-265.2	-248.9

Mean values of $\delta^{18}O$ in the ice wedges from three sections varies in a narrow range from -34.36 to -34.12 ‰, and $\delta^{2}H$ values from -266.3 to -264.5 ‰. Based on detailed isotope data (170 samples), the average January temperature of the Late Pleistocene was calculated from 25 to 30 cal. ka BP and from 42 to 49 cal ka BP for the Batagay section and for a number of supporting sections, in the north-west of Yakutia. It was shown that the lowest average

January air temperature in this period was in the Batagay region (-51°C, average january temperature is -45°C), while in areas located 500-600 km to the north, it was 4-5°C higher 25 to 30 cal ka BP and 5-7°C higher from 42 to 49 cal ka BP. These severe winter climate conditions are explained by the existence by stable Yakutia anticyclone in the Late Pleistocene (from 25 to 49 cal ka BP), which still exists at present. The work was supported by the Russian Scientific Foundation (grant No. 19-17-00126 - field studies) and Russian Foundation for Basic Research (grant No. 18-05-60272 "Arctic" -radiocarbon and stable isotope composition).

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Can the probability density distributions of radiocarbon and luminescence dates refine our knowledge of paleoenvironmental changes during MIS 3-2?

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The Interpleniglacial period (MIS 3, ca. 57 – 29 ka, Lisiecki & Raymo 2005) was characterized by numerous both rapid (on annual to decadal timescales) and long-term (centennial to millennial) climatic oscillations and extreme environmental changes - known as Dansgaard-Oeschger (D-O) cycles (Dansgaard et al. 1993; Huntley et al. 2003; Wohlfarth, 2008). These cycles involved strong changes in the northern hemisphere - high-latitude air temperature, hydroclimate, and atmospheric circulation transitioning in a matter of decades (Sadatzki et al. 2019) and also influenced Eurasian and tropical climates. In turn, the MIS-2 period (ca. 29 - 14.7 ka BP) was characterized by severe climatic conditions.

The recognition of rapid climate oscillations in the isotopic data from the Villars cave stalagmite (SW France, Gent et al. 2003) may support the hypothesis that the Dansgaard-Oeschger cycles recorded in the Greenlandic ice core could also be recorded in terrestrial sediments. Such assumption is justified also by the fact that very rapid changes in the Late Glacial/Holocene transition recorded in the Greenland ice cores were also recognized in Poland, in the terrestrial environment, e.g. in the sediments of Lake Gościąż (Goslar et al. 1993), site Koźmin Las (Dzieduszyńska et al. 2014) or palaeo-lakes Żabieniec (Twardy et al. (eds.) 2010) and Trzechowskie (Słowiński et al. 2017). Therefore, it seems that also for the earlier period, terrestrial environments could register the same cycles of warming and cooling as those recorded in ice cores. It should be also noted that previous study for Subcarpathian Basins (Gębica et al. 2015; Starkel et al. 2017), for which we have numerous base of investigated sites and dates, as well as research in the Holy Cross Mountains (Ludwikowska-Kędzia 2000, 2018), showed that collective reconstructions (including analyses of summed probability density distributions of radiocarbon and luminescence dates) can help identify warming/cooling periods during the Interpleniglacial time.

The present research concerned the area of the Subcarpathian basins (Gębica et al. 2015, Starkel et al. 2017), the lowlands of central Poland (Rotnicki 1987, Krzyszkowski 1990, 1991,

Kasse et al. 1998, Petera 2002, Krzyszkowski & Kuszell, 2007, Wachecka-Kotkowska et al. 2014, 2018, Dzieduszyńska 2019,), the Holy Cross Mountains in the area of highlands of southern Poland (Ludwikowska-Kędzia 2018) and one site in the Sudeten Foreland (Krzyszkowski et al. 1995, 1999, 2001). The main goal of the research is verifying the number of "warming-cooling" cycles recorded during MIS 3-2 period in Poland, to the south of the last glaciation's maximum range (LGM) in the lake, fluvial, aeolian and slope sedimentary environments and explore how recorded oscillations are correlated with changes registered in Greenland ice cores.

For MIS 3-2 periods, there is no single site (or sites) in Poland in which a continuous record of climate change would be preserved. Because of that, the authors decided to gather and analyze scattered information. Joint analysis of data from a larger area may reveal the records of more events than from individual sites. The authors undertook an attempt to assemble data and check whether the available results of ^{14}C and luminescence dating presented in the form of probability density distributions and compared to the Greenland isotope curve (Rasmussen et al. 2014) will allow their reinterpretation and are consistent with the hypothesis that the number of cycles of "warming-cooling" recorded in terrestrial sediments is of the same order as in the ice-core sediments of Greenland.

From mentioned areas, the authors collected information on 477 radiocarbon dates and 160 luminescence dates in the range of 10-50 ka BP. The tools that will be used is analysis of PDF distributions (Michczyńska et al. 2007, Gębica et al. 2015, Starkel et al. 2018, Dzieduszyńska 2019) and also KDE model (Bronk Ramsey 2017).

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Reinterpretation of the Late Glacial classic type localities compared to the new high resolution results from Polish part of European Sand Belt

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Climate changes and short-term oscillations from the termination of the last glaciation are derived (among others) from fluvio-aeolian succession in European Sand Belt (ESB). Abrupt changes of sedimentary environments in this succession are widely related to climate changes mentioned above. However, current bio- and lithostratigraphic models reveal considerable discrepancies when we compare it to deep marine and Greenland ice cores results. Current models are built on few absolute dating results obtained from particular sites. Problem with reliable dating of fluvio-aeolian succession has two main causes: (i) stratigraphy reduced to (mostly) uncalibrated radiocarbon dating; (ii) too few samples taken from the outcrops not crosschecked by luminescence dating.

One of the most important elements in the fluvio-aeolian succession are palaeosols. They have crucial significance for palaeoenvironmental reconstructions as well as for chronology based on radiocarbon dating method. Current biostratigraphy derived from Polish part of ESB links to biostratigraphic model established previously in Denmark. It means that soil processes were correlated with two main climate ameliorations in the Late Glacial - Bølling and Allerød interstadials. Last results obtained from different parts of ESB reveal possibility of alternative stratigraphic model closer to Greenland ice core. Therefore, we decided to calibrate uncalibrated radiocarbon dating results from classic type localities and compare to the results obtained during our studies. We choose eight key sites: Kamion-Młodzieszynek, Dobroń, Bełchatów-Miasto, Cięciwa, Jasień, Ignatówka, Bełżec, Malewszczyzna. In every site at least one palaeosol occurred within aeolian succession. We compared calibrated radiocarbon dating to the results obtained from three new key sites: Gołąb, Przechód and Teodorów. We also included radiocarbon and optically stimulated luminescence (OSL) dating results published recently from the Late Glacial palaeosols in Poland. This result database obtained for newly discovered places with preserved soil and aeolian succession combined with old calibrated (recalibrated) radiocarbon results allows us to draw unexpected conclusions. Fluvio-aeolian succession reveals more sensitivity on climate oscillations as it was assumed before. We detected three palaeosols related to particular warm oscillations in the Allerød interstadial and at least one paleosol from the Younger Dryas. We also assume that vegetation cover preserved in the initial part of the following coolings at least 50-100 calendar years.

Presented results were obtained with the support of Polish National Science Centre, contract number 2018/30/E/ST10/00616.

Local MRE on the Coast of Brazil: variations over the last millennia

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The radiocarbon (^{14}C) Marine Reservoir Effect (MRE) is the marine ^{14}C deficiency when compared to the atmosphere. Although the magnitude of this offset varies geographically, it tends to be relatively constant in open ocean regions that are not influenced by mixing with water carrying a different ^{14}C signal. In coastal regions, however, the scenario is considerably more complex and the MRE is influenced by carbon sources that exhibit a wide range of isotopic signatures. Indeed, the complexity of the carbon cycle in coastal systems demands extensive research for an accurate quantification of the MRE and its variability, which has the effect of hindering accurate ^{14}C chronologies on the coast. Here we evaluate the behavior of the local MRE offset (ΔR) in estuaries, where the interplay of the hydrography with factors such as the regional geology, upwelling and, especially, sea-level variations can contribute to a highly variable MRE. Using archaeological samples over the last 4kBP and pre-bomb shells from museum collections, we discuss the published data from the Southeastern coast of Brazil in the light of the Marine20 curve and distinguish temporal variations caused by regional factors.

INVITED

Constraining soil models with radiocarbon data: system age and transit time

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Quantifying the timescales associated with different mechanisms of C stabilization remains a critical task for predicting soil C sequestration potential. Although it has long been recognized that radiocarbon data provide critical information about how long C resides in or is respired by soils, finding ways to interpret radiocarbon data quantitatively remains difficult. This is because models must be used, and their parameters estimated by comparing radiocarbon predicted by the model with measured values. To complicate things further, for most mineral soils, single pool models are not sufficient to reproduce radiocarbon time series or carbon dynamics following disturbance. Choices of model structure will influence the inferred values of parameters like decomposition rates.

Faced with this challenge, there are several options. From the measurement side, we can try to link model pools to measurable fractions separated by biological, chemical or physical characteristics. We can also produce time series that can provide information about how bomb radiocarbon moves through the soil over time. From the modeling side, we can try to use metrics that can improve our comparisons with radiocarbon distributions, rather than just trying to match bulk measurements. For example, even simple models will predict not just the mean system age, but an age distribution that can be better matched against observations. Models can also predict the transit time, the age distribution of microbially respired CO_2. This in turn can be compared with incubations, including long-term incubations.

This presentation will give examples of comparisons of transit times and system age distributions as ways to provide greater confidence in using radiocarbon to quantify soil C dynamics.

Radiocarbon analysis of buried and surface soils for reconstructing the Neoglacial advances of alpine glaciers, SE Altai, Russia

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Radiocarbon dating of daily and buried soils in the head of trough valleys within the high mountainous southeastern part of Russian Altai (SE Altai) gives an opportunity to clarify the Neoglacial chronology and magnitudes of glacier advances in the northern segment of Central (High) Asia.

First results of studying the Holocene paleosols archives in the upper part of the Akkol valley (South Chuya Range) including chronological reconstruction of pedogenesis was reported by Egli et al (2014), and served as an impetus for specifying the extent of the Altai glaciers advance during the Akkem stage (4.9-4.2 ka cal BP). It was supposed that Akkem glaciers extended beyond the limits of further Neoglacial stadial advances during the Historical (2.3-1.7 ka cal BP) and Aktru (or LIA, 13th-19th centuries AD) stages. The chronological reconstructions are based on assumption that the Akkem moraine was formed in a time interval, which was characterized by lack of finds of paleotrees fragments above the modern tree line in the crest areas of the ridges, and was supported by radiocarbon dating results of peats above the Akkem moraine in the Aktru valley, North Chuya Range (Agatova et al., 2012).
In the Akkol valley, two youngest moraine complexes (Aktru and Historical stages) are the closest to the Sofiysky glacier, and the Aktru moraine overlaps the moraine of the Historical stage. Different age of these moraines is evidenced by their different state of preservation and by the age of larches, which settled the moraines surface. According to Egli et al. (2014), a daily soil profile near the front of moraines began to develop about 5.4 ka cal BP. These data cast doubt on the larger magnitude of the glacier advance during the Akkem stage. Our field investigations have confirmed the mid-Holocene pedogenesis in the head of the Akkol valley: lenses of humus material (sometimes with root detritus) of ~5.1-5.9 ka cal BP buried by fluvial and slope deposits were discovered on the left-bank terrace about 1 km downstream from the front of the moraine complexes.
So, buried soil horizons (which were not covered by glacial deposits) of ~5-6 ka cal BP and permanently developing during ~5.4 ka cal BP daily soils were detected in immediate vicinity of the Historical moraines. This fact suggests that in case of glacier advance about 4.9-4.2 ka cal BP, area of glaciation in the Akkem stage was similar or smaller than it was in the Historical Stage. Such a scenario of glacial dynamics in the SE Altai is closer to Neoglacial reconstructions within other mountain systems. A specific feature of Altai glaciations (which is also detected in some other mountain systems of Central Asia) is that the size of LIA (Aktru) glaciers reduced due to progressive aridity intensification in the second half of the Holocene.

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Towards the understanding of the present-day human impact on peatland deposits formed since the Late Glacial: a "retrospective" age - depth model of the Grel raised bog (Polish Inner Carpathians)

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The Grel raised bog is located in the Orawa-Nowy Targ Basin (Polish Inner Carpathians). In the 1960s, the maximum thickness of the peatland deposits was about 7.4 m (Koperowa, 1962). The pollen analysis performed at that time showed that the peatland deposits have been accumulated since the Oldest Dryas up to present days. The (only one) radiocarbon date (^{14}C) of the bottom parts of the deposits (transition: AL / YD) was approximated at 10.76±0.20 ka BP (K-529, Tauber, 1960; Koperowa, 1962). In 2012-2018, several peat cores were taken in the vicinity of the 1960s drilling. It was found that the thickness of the peat sequence has decreased from ca.7.5 m to ca. 4 m, while peat sediments/deposits are characterized by considerable compaction. The pollen analysis of the sampled sediments showed that despite the strong reduction of peat thickness during the last 60 years, the sediment stratification did not change. The profile of the bog was still complete, which was also confirmed by the 24 radiocarbon (^{14}C) dates made here (Michczyńska et al., 2018). The almost twofold decrease in the peat thickness was the result of the overdrying of the fen, associated with a drastic lowering of the groundwater table caused by the nearby Czarny Dunajec River incision into the bedrock by approx. 3.5 m, as a result of gravel exploitation and artificial regulation of the river channel (see: Zawiejska, Wyżga, 2010). Based on the PCA (Principal Component Analysis), a comparative analysis of both palynological profiles (1962 and 2018) was carried out, which exhibits a high consistency of the percentage of pollen of several taxa (trees, shrubs, herbs) for the 10 horizons occurring in both profiles. On the basis of the age-depth curve made for the new profile (based on 24 ^{14}C dates), the modelled age for the above-mentioned compliance levels was obtained and based on this age, a "retrospective" age-depth model was elaborated for the Koperowa's (1962) profile, taking into account the radiocarbon dating made at that time. The analysis of both profiles showed that the compaction of sediments did not occur proportionally in the entire sequence: it differed (somewhere significantly) for the depositional levels accumulated during the individual chronozones. Human impact on the Grel peatland (in the last 60 years) had a significant impact on changes in the thickness of individual depositional sections/levels in the fen profile. The conducted research indicates that contemporary human activity may significantly affect the entire profile of peatlands (not only their upper parts, as previously was considered), what should be taken into account during the reconstruction of the palaeoenvironment (palaeoclimate) based on multiproxy analysis of the peatland deposits.

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New radiocarbon data from the paleosols of the Nyírség blown sand area, Hungary

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The Nyírség is the second largest blown-sand dune area in the Carpathian Basin, which was formed on the alluvial deposits of the Tisza and Bodrog Rivers and their tributaries. The alluvial fan dried out and the wind became the dominant geomorphic agent. The first significant sand movement was in the Upper Pleniglacial and the Late Glacial. During warmer and humid periods, where the paleo environmental conditions were favourable, soil formation occurred.

Despite many ideas about the age and processes of sand movements and paleosol formation, there are still some uncertainties in this relations in the Nyírség, eastern Hungary. The major aim of the present study was to clarify the chronology of fossil soils and blown-sand layers in the sand dunes of the Nyírség using ^{14}C dating on soil and charcoal samples.

Charcoal and soil samples was collected from buried paleosols from different 8 sand quarries (Gyüre, Vásárosnamény, Kótaj, Kántorjánosi, Nyíradony, Máriapócs, Lövőpetri and Petneháza) for ^{14}C dating. The bulk organic carbon content of the buried soil and charcoal pieces recovered from buried fossil soil layers allowed parallel ^{14}C AMS dating in several cases.

The new radiocarbon results indicate paleosol development during Younger Dryas, while the preceding interstadial was assumed as a cold and dry period when only sand movement occurred in the area. Our results also confirm and support the previous assumptions, that in the Late Glacial, the first paleosol development period was during the Bølling-Allerød Interstadial. Four soil-forming periods could be determined during the Holocene (Preboreal, Boreal, Atlantic, Subatlantic). We have also indirectly identified sand movements during the Oldest Dryas, Younger Dryas, Preboreal, Boreal and Subatlantic phase in the study area.

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Carbon dating of agricultural soils and further understanding the transport of CO_2 gas using isotopes

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CO_2 is a greenhouse gas which is significantly emitted by agricultural soils through the decomposition of plant residuals and soil organic carbon. Carbon isotopes can be used in determining the source of the CO_2, origin of the carbon, and the age of the CO_2 emissions. This study investigates the transport of CO_2 gas through agricultural soils using carbon isotopes ^{14}C and ^{13}C to complement concentration and production rate measurements in an agricultural setting in Eastern Ontario. Traditional radiocarbon dating measures time through loss by decay, while recent dating is based on matching measurements with the atmospheric $^{14}CO_2$ signal ($F^{14}C$) generated by nuclear bomb testing in the 1950s and 1960s.

CO_2 emissions were analyzed from soil core sections together with soil-probe gas samples and surface flux chamber samples collected from the study area. Soil cores were collected from 0-90 cm at 7.5 cm increments and placed into IsoJar® microcosms for a period of one month. CO_2 in-growth was monitored to provide production rates and samples for ^{14}C and ^{13}C analysis. The radiocarbon data for the microcosms showed that values increase with depth from the current value 1.00 $F^{14}C$ at the surface to an attenuated peak of 1.04 $F^{14}C$ at a depth of 30 to 40 cm and then decrease to values below 1.00 $F^{14}C$. The data collected from the soil-probe gas showed a significant depletion in comparison to the microcosms and the surface chambers. The soil cores were subsequently analyzed by a selective leach oxidation protocol to sample decreasingly labile solid organic carbon. This involved placing the weighed soil samples into MilliQ water for 24 hours, before being passed through two sieves, 63 microns and 0.45 microns. The DOC leachate was collected and analyzed for ^{14}C and ^{13}C. The two solid soil fractions were then dried, treated with HCl to remove carbonate and then oxidized under vacuum with 5% H_2O_2 yielding CO_2 and residual soil carbon for ^{14}C and ^{13}C. The radiocarbon analysis of these variously labile fractions will be used to establish their age and relative contributions to CO_2 emissions from different depths in the soil profile.

^{14}C and stable carbon isotope composition of soil organic matter fractions in Ultisol profiles, Calhoun CZO, South Carolina USA

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Soil organic matter (SOM) dynamics are very significant to the global carbon cycle. The deforestation process for agricultural use releases large amounts of carbon to the atmosphere, mainly from cultivation accelerating decomposition of SOM. Here we present a study of carbon isotope composition of different SOM fractions in two Ultisol soils: one of them was used for growing cotton since the beginning of 19th century through 1920s, with the forest regenerating naturally after cultivation, and another soil believed to have been never used for cultivation. Two different methods were used to separate SOM fractions: 1) physical separation based on the particle size and their density. There were separated fractions>250 μm, 250-53 μm and 53 μm; the fraction 250-53 μm was separated in two density fractions; 2) chemical separation based on binding of SOM with minerals. From the bulk soil samples, the humic acid (HA) fraction was extracted with mix of Na4P2O7 and NaOH, which leaves behind the insoluble humin fraction. The separated fractions were analyzed for $\delta^{13}C$, using Costech ECS 4010 Elemental Analyzer - Thermo Fisher Delta V, and for $\Delta^{14}C$, using NEC 1.5SDH-1 Pelletron compact AMS system.

SOM accumulated in the top 50-60 cm is tracked by its distinctive ^{14}C signature, acquired after massive atmospheric nuclear tests in 1960's. Our data combined with model simulations indicate that not only a few decade old mostly conifer forest but also wide broad leaf reference forest rapidly incorporate "bomb" carbon in SOM and all its fractions. The maximum of $\Delta^{14}C$ =200‰ was in HA from the surface horizons of the reforested soil and a minimum -240‰ was observed in heavy fraction of AB horizon on the reference site. In general the $\delta^{13}C$ increases from the top AO to AB horizon in the most physical and chemical separated fractions for both sites from -28.3‰ till -24.6‰. Combined $\delta^{13}C$ and $\Delta^{14}C$ analyses on SOM fractions are the great potential for studying the turnover at meso- and long-term scale.

The sedimentation rate of bottom sediments in the Salęt-Ruskowiejskie lakes complex and its climatic and anthropogenic conditions

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The Salet Duży, Salęt Mały and Ruskowiejskie lakes are located in the Mrągowo Lake District (Poland NE), morphologically in a subglacial channel. The main feature of this region is a long history of settlement with archaeologically confirmed evidences reaching 3200 BC. Five cores of sediments were collected with the use of Więckowski auger during the winter season (from ice): single ones from the Ruskowiejskie and Salęt Mały lakes and 3 from the Salet Duży lake. The length of the obtained cores ranged from 2.25 to 15.2 m. They were consisting of carbonate-organic-mineral or mineral-organic-carbonate sediments (Salęt Mały), and closer to the eastern shore of Salęt Duży Lake with a significant share of sand and gravel. Loss on ignition (LOI), the content of carbonates assesed by the Scheibler method and the content of selected macro and trace elements were analyzed with a average resolution of 5 cm; in case of not much macroscopicaly differenciated parts of the core (i.e. middle part) every 10 cm. All together 27 samples were radiocarbon dated. The obtained date from the basal (bottom) peat indicates an Alleröde age. Taking into account the variability of lake sediments, 5 different series were distinguished in terms of the lithological type of sediments. They were correlated then with palynological data and the local/regional history of settlement. Prehistoric human activity is marked by non-simultaneous (asynchronous in time) enrichment in most of the analyzed elements and a significant periodic supply of mineral terrestrial deposits. However, from the Middle Ages period, the dominance of mineral sedimentation (70-80%) and a similar level of pollution is observed at every analysed site, what means it began almost at the same time. The average annual pre-antropogenic sedimentation rate ranged from 1.04 mm to 1.28 mm, and from the early Middle Ages it started to be more varied, namely from 0.8 mm/year in the site located at bay of Salęt Duży to over 4 mm/year in Salęt Mały (in the site located at deepest part of lake), which may be the result of the settlements location, that were mostly in the northern and eastern sides of this lake.

Seasonal variation of carbon isotope composition of particulate organic matter at a small and shallow lake, Kiba-gata during 2016-2019

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Lake Kiba-gata is located at Komatsu City and has a semi-closed, small and shallow properties. An annual average of chemical oxygen demand (COD) concentration is 6-7mg/L and over 3mg/L of the environmental standard relating to water pollution in this lake type during last 10 years. Understanding of controlling factors for organic pollution is needed to reduce the pollution and perform counter measures. Our research is observed for a positive correlation between COD and organic carbon concentration during a year of 2017. The aim of this study is to identify dynamics of organic matter in the lake by using carbon isotopes ($\delta^{13}C$ and $\Delta^{14}C$) of particulate organic matter. We carried out monthly sampling at a site of inflow river and the centre of lake from January 2016 to December 2019. The suspended solids were isolated from 60 L of surface lake and river water by using continuous flow centrifugation method.

The POC concentration shows seasonal variation with 0.44 mg/L to 4.2 mg/L: the higher concentration was observed at summer season and lower concentration was observed at winter season. $\delta^{13}C$ value of POC has variation from -33.5‰ to -27.4‰ in winter (December-February: average of -30 ± 3‰) and from -28.3‰ to -25.3‰ in summer season (June-August: average of -25 ± 1‰). The higher $\delta^{13}C$ value shows the contribution of phyoplankton during summer-fall. $\Delta^{14}C$ value of POC shows a wide range from -196‰ to -33‰ and similar seasonal variation with POC concentration. An average value of $\Delta^{14}C$ is -144 ± 35‰ for the winter and -56 ± 17‰ for the summer. There is a positive correlation between the POC concentration and $\Delta^{14}C$ except for some of winter samples. It appears a positive correlation between $\delta^{13}C$ and $\Delta^{14}C$ value, but more scatter plotted in comparision with the POC-$\Delta^{14}C$ correlation. The higher $\Delta^{14}C$ value and POC concentration indicate the higher contribution of apparently younger organic matter to suspended solids. These results indicate that the POC concentration is controlled by the activity of phytoplankton in the lake during spring to autumn season.

Establishing high resolution geochronology using algal rims in relative-sea level studies – Examples from the eastern Adriatic coast

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Among fixed biological indicators, bio-constructions formed by the alga *Lithophyllum byssoides*, are one of the best sea-level indicators on rocky coasts. Their vertical precision (±10 cm) in microtidal environment comes from the restricted environmental conditions of the alga as its living range is constrained around sea level. In order to approach the ^{14}C reservoir effect which could have an important influence on the final ^{14}C results we engaged different studies of marine radiocarbon reservoir effects (MRE) of the alga and shells in the Adriatic and in the other parts of the Mediterranean using samples of known age from museum collections. The corrections of MRE and local DR are fundamental particularly for the short, late Holocene sea-level and palaeoenvironmental chronologies.

Here we present examples of precise relative sea-level (RSL) reconstructions for the past ~3000 yrs based on the studies of *Lithophyllum* rims from Istrian peninsula in the northern, and from Lopud Island in the southern Adriatic. The chronologies were based on 47 (in Istria) and 23 (at Lopud Island) radiocarbon dates which were accurately calibrated in order to provide precise relative sea-level curves, to relate sea-level changes to periods of climate changes and to try to distinguish land-level changes in the studied area. The RSL reconstructions were quantitatively analysed using an error in-variables integrated Gaussian process (EIV-IGP) model to identify sea-level trends with full consideration of the available uncertainty.

The high-resolution geochronology obtained at Lopud Island allows us to distinguish the effects of coseismic movements on RSL histories what confirmed the precision of *L.* byssoides bioconstructions not only in the studies of relative sea-level variations but also in the studies of palaeoearthquakes in seismotectonically active areas. Also, it confirmed the importance of precise determination of marine radiocarbon reservoir age of the alga as the geomorphologic consequences of known AD 1667 Dubrovnik earthquake could be accurately determined. Consequently, the study of algal rims could also allow assessment of palaeoseismicity.

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Carbon sources and sequestration: 14C Ramped Pyroxidation in aquatic samples

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Sequestration of organic carbon in aquatic sediments can depend on its source and potential lability. Studies have shown that bulk lake and marine sediment comprises carbon of different origin but its source has been difficult to attribute. A new Ramped Pyroxidation/Combustion (RPO) system in the ^{14}CHRONO Centre has been established. RPO is a technique that incrementally heats a sample, and allows for collection of the CO_2 produced for radiocarbon analyses. The results show its utility in partitioning carbon sources in lake sediment (Rostherne Mere, UK, Santa María del Orolake, Mexico), and arctic marine sediment (Chukchi Sea and Beaufort Shelf). RPO and 2-stepped combustion[1]. ^{14}C indicated multiple carbon sources in Rostherne Mere sediment, some of which could be attributed to the construction of a sewage treatment works (STW) on the lake shore, and subsequently inputs from this STW. RPO identified 3 carbon fractions in Mexican Lake sediment, which provided a more accurate chronology, partitioning the contemporaneous sediment date from offsets induced from volcanic activity in the area. Results from Arctic marine sediment demonstrated inputs of carbon from ancient permafrost, providing a means to refine the chronologies and a basis for future research linked with carbon loss from thawing permafrost. The facility has also been used to analyse preservative in conserved museum pieces and other materials.

[1]Keaveney et al. 2020. Journal of Palaeolimnology 64 347-363

Freshwater reservoir effect variability of bohemian archaeological sites

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The freshwater reservoir effect is always a potential issue when radiocarbon dating shells and bones from sites near rivers or lakes. The paper compares ^{14}C results of herbivore and fish bones, the bones of the European pond turtle (*Emys orbicularis*), and shells of river mussels (*Unio* sp.) from archaeological features of the same expected archaeological age in the rivers of the Bohemian Basin, Czech Republic. In some cases, radiocarbon values from river animals compared to sheep and cattle bones show significant differences in radiocarbon age; this is generally the case when comparing shells of river mussels and herbivore bones, which show a difference up to fifteen hundred years, as well as herbivore and fish bones, indicating a difference up to several hundred years. The turtle bones, when compared to the herbivores, show high variability in radiocarbon age (from almost no difference at all up to several hundred years). The paper debates possible causes of data variability, such as the age of the particular individuals, diet, and local environmental conditions. In addition to the freshwater effect debate, our paper brings new evidence on the temporal occurrence of *Emys orbicularis* in Czech lands backed up by radiocarbon dating. Being aware of the potential freshwater reservoir effect should increase the requirements for selecting samples for radiocarbon dating.

Carbon and nitrogen isotopic composition in karst subterranean environments as an example of the Eastern Europe and the Caucasus caves.

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One of the informative instrumental methods of studying the mechanisms of self-regulation of subterranean systems (caves) and organomineral interactions in the soil-like bodies in caves is the method of stable isotopes. Currently, investigations in the field of the isotopic composition of carbon and nitrogen pools in cave ecosystems during their auto-phototrophic formation are scarce. The objective of our research was study the common factors of the fractionation of stable isotopes C and N in phototrophic communities and soil-like bodies (soloids), forming under them, in extreme environmental conditions.

The phototrophic communities (cyanobacteria, mosses, algae, ferns) locate at the entrances of the cave, lit by sunlight, and also develop under the artificial cave lighting. For such phototrophic organisms, there is a recognized term «lampenflora». At sites where the lampenflora colonizes some spots we found the transformation of mineral substrates by soil-like type. These soil-like formations represent the contact zone between the biota and the lithological basis, develop sub-horizontal layers with different properties, characterized by the tiny thickness (first millimeters).

The data of carbon and nitrogen isotope composition for the biota and soloids from karst caves in the different -physico-geographical zone are generalized and systematized in this work. Based on the obtained data, the hypothesis of specificity of gas composition at the subterranean ecosystem atmosphere was put forward.

The objects of our research were localized in limestones and gypsum regions located at the different natural zones: at the Middle Taiga (cave Divia), at the South Taiga (cave Kungurskaya), at the zone of the Subtropical Leafed Forests (caves: Akhshtyrskaya, Novoafonskaya).

During the analysis, we found the difference in isotopic ratios in the biomass of terrestrial autotrophic organisms in comparison with samples of lampenflora in cave habitats. The range of values $\delta^{15}N$ is within -8.10‰ to +3.55‰ for subterranean habitats and from -3.74‰ to +5.23‰ for the day surface. The biomass of cave environments is also saturated with "light" isotope ^{12}C. Probably because of the effect of low gas exchange with the atmosphere and high intensity of microbiological and geochemical processes the multiple assimilations of CO_2 occurs. This partly resembles the so-called "canopy" effect. However, in caves it repeatedly amplifies. This hypothesis is confirmed by the trend of accumulation of the ^{12}C isotope in lampenflora and soloids with distance from the entrance of the cave, which is due to the reduction of air circulation. The shift of $\delta^{13}C$ ratio for Novoafonskaya cave range of values is -37,45‰ to -47,16‰ and -26,40‰ to -45,48‰ (for lampenflora and soloids). For the Kungurskaya cave reveals a similar pattern: -26,23‰ to -41,87‰ and -25,45‰ to -36.65‰. There was no pronounced trend of $\delta^{15}N$ ratios in cave phototrophic communities

with distance from the entrance of the cave. Measurements of CO_2 concentrations in the Novoafonskaya cave indicate an increase in the concentration of carbon dioxide at the distant halls of the subterranean landscape (~1500 ppm) relative to the background value (~500 ppm). In addition, limited air circulation contributes to the accumulation of biogenic CO_2 in the cave atmosphere. This explains the source of "light" carbon ^{12}C in the biomass of lampenflora. The change in the isotopic ratios after the deposition of the biomass (only for mosses and ferns) into the cave's soloids (Akhshtyrskaya cave) showed a shift toward saturation with a heavy ^{13}C and ^{15}N which demonstrates the well-known pattern for soils on sun-light surface.

Recently, we have been started radiocarbon studies that will allow us to determine the rates of carbon exchange in the soil-like bodies - biota - atmosphere system of the cave and to determine the age of soil bodies emerging in the caves.

^{14}C dating of sea shells for geomorfology studies

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This paper gives an overview of the Accelerator Mass Spectrometry at the 1 MV Tandetron and of the ^{14}C dating of sea shells for geomorphology studies. Accelerator Mass Spectrometry (AMS) is today the most sensitive isotopic analysis method known. The AMS sensitivity can reach 10^{-15} scarce isotope (^{14}C)/ abundant isotope (^{12}C). Due to its exceptional sensitivity, this method has opened a very wide range of applications in various fields: **geomorphology**, medicine, archaeology, atmospheric physics, paleoclimatology, astrophysics, nuclear physics, nuclear pollution tracking, etc.

The isotope with mass 14 known as radiocarbon is one of the unstable isotopes of carbon with widespread applications in the scientific world. The use of ^{14}C as a „clock" for estimating the age of various historical and pre-historical samples is one of its most important applications.

Sampling, sample preparation and measurement of the ^{14}C content are important steps in obtaining reliable radiocarbon ages. In the ^{14}C AMS technique, the element of interest (sample carbon) is chemically separated from the original sample, converted to graphite, pressed into a cathode (sample target holder) where it forms a solid graphite layer and is then placed into a sputter ion source of an accelerator. Calibration of radiocarbon ages is the final step in establishing chronologies.

The main purpose of this study on the Black Sea samples is: to calculate the deposition rates of sediments in different underwater environments from the Black Sea, to date underwater geological events as: turbidite flows, landslides, etc., to date the main incisions of the canyons on the continental platform and flexure zone.

Black Sea is a very peculiar basin, due to its character of a semi-enclosed sea and its episodic connectivity with the Mediterranean Sea and further with the world ocean during Quaternary. This peculiarity produced a complex pattern of paleo-shorelines and paleo-hydrography, imprinted in the sedimentary structures deposited and/or eroded, on the actual continental platform and in the shelf break area.

The sea level variations has been convoluted with other local, regional active tectonics and glacial isostatic adjustment; as a result the morphology of the seabed and the shallow sub-structure of the sea bottom, that are the main geological and geomorphological features we can measure and depict in order to decipher the evolution of the paleo-shorelines and paleo-hydrography in general, are very complex in the NW Black Sea.

Evaluating sources and cycling of particulate organic carbon in Baffin Bay: a $\Delta^{14}C$ and $\delta^{13}C$ approach

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The impact of global climate change on Arctic ecosystems and the marine carbon cycle is poorly constrained. Little data exists regarding carbon cycling in Baffin Bay, an important region that connects the Arctic and Atlantic. Currents flowing out from Baffin Bay influence meridional overturning circulation in the Labrador Sea. With the Canadian Arctic warming twice as fast as the rest of planet, constraining the biogeochemical cycling of the major marine carbon reservoirs in this region is critical. Particulate organic carbon (POC) is the carbon reservoir central to the biological pump and is responsible for the removal of carbon fixed from our atmosphere by primary producers to the deep ocean where it is buried. Stable carbon and radiocarbon isotopic measurements are powerful tools for evaluating the sources and cycling of POC. Here we evaluate the stable carbon ($\delta^{13}C$) and radiocarbon ($\Delta^{14}C$) values of POC collected throughout Baffin Bay on a cruise aboard the *CCGS Amundsen* ice breaker in 2019. Our results suggest that POC in Baffin Bay is comprised of multiple carbon sources. Autochthonous (*in situ* phytoplankton production) and allochthonous (resuspended marine sediment, terrestrial material and/or advected suspended POC) components make up variable proportions of POC sampled. Positive POC $\Delta^{14}C$ values in central Baffin Bay indicate the presence of "bomb" radiocarbon, indicating that some fraction of Baffin Bay POC is decades old. These data provide novel constraints on the cycling of POC in Baffin Bay, and represent baseline data for identifying future changes in carbon cycling in the Canadian Arctic.

Record of environmental changes in the sediments filling the oxbow lakes (on selected examples from Vistula and Bug river valeys)

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On the basis of vertical variability of several physicochemical features of sediments filling selected oxbow lakes in the valleys of the Vistula and Bug rivers, the phases of human economic activity and changes in climatic conditions in the sub-Atlantic period were reconstructed. The samples were taken from the deepest parts of oxbow lakes in winter from ice and in summer from boats. In the samples from bottom sediments there were analyzed, among others, organic matter content, carbonate content, bulk density, trace elements content and magnetic suceptibilty. The age of the sediments was determined by the radiocarbon method and for the youngest layers with the use of ^{137}Cs and ^{210}Pb. The rate of sediment deposition in the analyzed oxbow lakes depended on the distance from the active river channel, time of cut off and loss of hydraulic contact, but most of all on human activity both in the immediate vicinity of the oxbow lakes and in the entire catchment area. On the basis of the examined physicochemical parameters of the sediments filling the oxbow lakes, it was possible to distinguish several deposition phases that can be correlated with historical or prehistoric periods of human activity.

Dissolved Organic Radiocarbon in the Pacific, West Indian and Southern Oceans

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We report marine dissolved organic carbon (DOC) concentrations, and DOC $\Delta^{14}C$ and $\delta^{13}C$ values in seawater collected from the Southern Ocean, Pacific and Indian Oceans on GOSHIP cruises. The aging of ^{14}C in DOC in Circumpolar Deep Water northward from the Southern Ocean indicates that the transport of deep waters northward is the primary control of ^{14}C in DOC. Low DOC $\Delta^{14}C$ and $\delta^{13}C$ measurements between 1,200m and 3,400m depth may be evidence of a source of DOC produced in nearby hydrothermal ridge systems (East Pacific Rise).

Isotopic studies of refractory dissolved organic carbon in the global ocean reveal the influence of heterotrophic bacteria

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Dissolved organic carbon (DOC) is the largest exchangeable pool or organic carbon in the ocean, similar in size to atmospheric carbon. DOC is formed in the surface ocean through phytoplankton photosynthesis and subsequently remineralized, transformed, or transported to the deep ocean through various biogeochemical processes. Radiocarbon analyses have shown that on average, DOC is >6000 ^{14}C years old in the deep ocean, and that >95% of total DOC is resistant to further biological degradation, or refractory DOC (RDOC). The mechanisms that facilitate the formation and cycling of RDOC are under investigation to better understand what drives the long residence time of deep-ocean DOC. Solid-phase extraction is a commonly used technique to isolate DOC (SPE-DOC) for subsequent analyses, and typically captures the low molecular weight, older portion of DOC that represents RDOC. We isolated SPE-DOC in the surface (0-200 m) and deep ocean (2000-4000 m) along three GO-SHIP Repeat Hydrography Transects in the Eastern and Central Pacific, Southern, and Indian Oceans (P16N, P18, and IO7N). Radiocarbon and stable carbon isotope analyses show that SPE-DOC has lower $\Delta^{14}C$ and $\delta^{13}C$ values than total DOC across the global ocean. The large meridional span in this $\Delta^{14}C$ dataset allows for the first regional estimates of RDOC abundance which may aid future ocean biogeochemical models. Low SPE-DOC $\Delta^{14}C$ and $\delta^{13}C$ values point to the microbial carbon pump (MCP) as a major driver of the marine carbon cycle through the removal of biomolecules with high $\delta^{13}C$, and addition of refractory products that resist degradation, driving low $\Delta^{14}C$.

Abstracts of poster presentations

[A1] Carbon-14 measurements in Air Samples

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Carbon-14 is a pure beta emitter (E_{max}-156 keV) with a half-life of 5730 years. ^{14}C is formed naturally by cosmic neutron interaction with atmospheric nitrogen ^{14}N (n, p)^{14}C. In nuclear reactors, ^{14}C is produced in the fuel, core structural materials and in the moderator by neutron reactions with oxygen, nitrogen and Carbon.

[A2] Fossil fuel environmental contamination: a strategy using radiocarbon, n-alkanes, and algae

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Fossil fuels are of utmost importance to the world we live in today. However, their use can cause major impacts on the environment, especially on water resources. In this regard, algae have been intensively used as a strategy for remediation and monitoring of environmental pollution due to its efficient absorption of contaminants. We have run an indoor experiment using seaweed samples collected in Niterói/RJ. They were contaminated with kerosene and diesel, analyzed by radiocarbon (14C) accelerator mass spectrometry (AMS) in order to measure the biogenic fractions and by n-alkane quantification with gas chromatography to evaluate bioaccumulation in function of the dosage of contaminants. The biogenic content measured by radiocarbon analysis resulted in 95.6% for algae contaminated with 10 mL of kerosene and 67.6% for algae contaminated with 10 mL of diesel. The maximum intensity of n-C17 n-alkane in algae with 5 mL, 10 mL, and 15 mL of diesel, respectively, was 768.2, 1878.1, and 5699.2 ng.g-1, while the maximum concentration of n-C27 in algae with 5 mL, 10 mL and 15 mL of kerosene was 3.3, 35.9, and 150.3 ng.g-1. For both contaminants, their incorporation into algae increases as the contamination dosage increases, making this methodology an effective technique for monitoring and remediation of urban aquatic ecosystems.

[A3] Estimation of the contribution of fossil and non-fossil emissions in atmospheric aerosols from Ciudad Universitaria in Mexico City using Radiocarbon analysis.

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In this work, Radiocarbon analysis of the carbonaceous fraction of atmospheric aerosols was used to identify the fossil or modern origin of the emitting sources in Mexico City. Two campaigns were conducted in the cold-dry period (November-December) and warm-dry period (February-April) in 2015. A thermal protocol was established to extract Organic Carbon from Total Carbon.

Radiocarbon content of total carbon (TC) and organic carbon (OC) extracted from collected quartz filters was analyzed using the Accelerator Mass Spectrometry technique available at LEMA Laboratory of the Institute of Physics of the Universidad Nacional Autónoma de México.

There was not a clear trend associated to the period of the year: Non-fossil contribution of the OC was lower than fossil contribution in November, but at the beginning of December this trend was inverted, reaching high levels in Christmas and New Year. These are two of the main holydays in Mexico, and important emissions of non-fossil OC were measured, originating mainly by tires burning and use of pyrotechnic fires. These values indicate that the majority of OC from pyrotechnic fires may come from biogenic sources.

Radiocarbon analysis by AMS of the two fractions: total and organic carbon, allowed to identify the contribution of fossil and no fossil carbon sources in each period.

Acknowledgements

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[A4] Possible drivers of fossil fuel CO_2 in the Metropolitan Area of Rio de Janeiro: A comparison analysis between $^{14}CO_2$ from Ipê Leaves and Socioeconomic Conditions

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Effective procedures for estimating fossil fuel-based carbon dioxide ($FFCO_2$) emissions have been advanced by researchers to determine the influences of demographic factors, or long-range patterns of sources and dispersion. The tools applied are often indirect statistical analyses of consumption-based emissions or direct measurements of $^{14}CO_2$ in air or plant samples. Worldwide applications have been somewhat fragmented and mostly limited to developed countries. Furthermore, connections between urban $FFCO_2$ spatial observations and urban characteristics still lack more in-depth/broader/wider complete discussions, particularly considering environmental public policies. The Metropolitan Area of Rio de Janeiro (MARJ) has a population density of 1725 inhabitants/m^2: a high conurbation level and an equally high industrial and vehicular activity. A fast urbanization process lacking overall adequate infrastructure, combined with intense migration from Brazil's poorest regions, has resulted in a severe social gap, leading to the most unequal metropolitan area in Brazil. Here, we reevaluate a previously published $FFCO_2$ estimate distribution attained from a 2015 ^{14}C time-integrated mapping of Ipê leaves from the MARJ, Brazil (Santos et al., 2019). This work aims to capture the relationship between $FFCO_2$ hotspots and socioeconomic conditions such as population density, income, urban mobility, and the presence of urban trees. Initial results suggest that, contrary to what has been observed at greater scales of analysis, population density is not necessarily associated with high $FFCO_2$ content at the metropolitan scale, due to the greater inequality of segregation in Rio de Janeiro. Poor suburban regions, such as the Baixada Fluminense, although characterized by dense population, are not the most polluted by $FFCO_2$, results reinforced by the income data map. This suggests that poorer populations would correspond to lower per capita emissions, despite being the most vulnerable to climate change, clearly exposing environmental injustice at the metropolitan scale. These results will be presented and discussed, along with further recommendations for sampling for ^{14}C analysis to better represent the area studied, particularly when it comes to the urban and metropolitan scales. This initial attempt was performed by overlaying maps, but future studies could rely on correlations, spatial regressions, and other quantitative and qualitative analysis tools.

Santos et al., 2019. Assessment of the regional fossil fuel CO_2 distribution through $\Delta^{14}C$ patterns in Ipê leaves: The case of Rio de Janeiro state, Brazil. *City and Environment Interactions* 1: 100001

[A5] Combined radio- and stable carbon isotope analyses for source identification of PM2.5 carbonaceous aerosol in Debrecen, Hungary

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Air pollution caused by aerosols has become a serious issue in many countries over the world. Atmospheric aerosols evidently have adverse consequences on the environment and public health, especially in urban areas.

In our study, 73 filters of $PM_{2.5}$ aerosol, covering a period from 12.2012 to 07.2014, were analysed in Debrecen, Hungary. In addition to mass concentration data, the OC/EC ratio of weekly samples and ^{14}C and stable carbon isotopic composition of integrated monthly samples were measured and evaluated with the aim of a better source identification. While the seasonality of mass concentrations of carbonaceous species is due to the variation of meteorological parameters such as outdoor temperature, precipitation and height of planetary boundary layer, the variation of ^{14}C and $\delta^{13}C$ values denote the seasonal effect of such aerosol sources as biogenic emission, transportation or biomass burning.

Based on our result, the mean value of contemporary carbon in TC for the heating periods was almost 3 times higher than in the summer months, while in case of the fossil carbon only an increase by a factor of 2 can be observed. The higher cotemporary carbon fraction of 0.77 in winter suggests that combustion of biomass fuels dominated over coal or oil. Considering the $\delta^{13}C$ result some C3 wood species, combustion of black locust, oak and beech was a significant factor in forming the mean $\delta^{13}C$ value of TC in wintertime aerosol. The surrounding trees and transportation, however, got a larger role in summer when the mean $\delta^{13}C$ value of the TC was more depleted. Later, applying HYSPLIT and FIRMS software, we could reveal that the less depleted aerosol values in the October months derived probably from agricultural C4 plant (probably corn) burning activity close to the southern and eastern Hungarian borders.

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[A6] C-14 and other radionuclides in the environment at the Lithuanian border region before the start of the Belarusian nuclear power plant operation

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Knowledge of the background activity concentrations of anthropogenic radionuclides before the start of operation of the new nuclear power plant in Belarus, BelNPP, is an issue of great importance for neighbouring countries. In this study, we provide the pilot characterization of the Lithuanian part of the 30-km zone of the BelNPP, emphasizing the terrestrial and aquatic samples to describe the preoperational radioecological state of the region. Key anthropogenic radionuclides (C-14, H-3, Sr-90, Cs-137 and Pu-239+240) potentially present in the releases from NPP were analysed in the variety of samples taken in 2017–2020.

The C-14 and H-3 levels in terrestrial plants within the 30-km zone of the BelNPP are close to the level determined by cosmogenic origin. The C-14 specific activity varied from 97.80 ± 1.30 to 102.40 ± 0.79 pMC. The H-3 specific activity in the issue-free water tritium form varied from 13.2 ± 2.2 TU to 20.8 ± 2.3 TU, which corresponded to the H-3 level of precipitation in this region. C-14 specific activity in macrophytes from the Neris River data showed significant variability depending on macrophytes ecological group. Floating macrophytes and habituating near shore zone (arrowhead, flowering rush and frogbit) had very similar just slightly depleted C-14 content as in atmospheric CO_2. Other, mostly submerged species (pondweed, Canadian waterweed and lesser water-plantains) were highly depleted with respect to C-14 and within uncertainty, the range had C-14 specific activity very similar to that of DIC.

The Cs-137 inventory in the pine forest soils of the Lithuanian part of the BelNPP 30-km zone varied from 930 ± 70 to 1650 ± 430 Bq/m^2. The Sr-90 inventory derived from the same samples were significantly lower (200 Bq/m^2) compared to that of Cs-137. The activity concentrations of Pu in soil and moss samples did not exceed 1 Bq/kg and were mainly due to global fallout after nuclear tests.

Our study evidenced that the main radioecological parameters of ecosystems located in the Lithuanian part of the 30-km zone of the BelNPP do vary in temporal and areal dimensions and should continually be observed and assessed when BelNPP is under operation.

[A7] Determination of the concentration of atmospheric carbon dioxide and its radiocarbon content in the southern region of Mexico City during the intensive burning of fireworks

ELBA ORTIZ and CORINA SOLIS

Approximately 22 million of people live in Mexico City and metropolitan area. The megacity is characterized by its joy and costumes, where holidays are celebrated by illuminating the sky with colors. And, even though, fireworks are not the main source of air pollution, they represent one variable that increases it. Thus, this work focused on the determination of atmospheric CO_2 and its ^{14}C content during the intensive burning of fireworks in Mexico City. Due to the high content of organic matter in pyrotechnics, it was expected that all along these days, where there is more use of firecrackers, the concentration of atmospheric CO_2 and mainly of ^{14}C will have a significant increment.

In December 2019, located at the south of the city, on a traditional home and commercial zone during the dry and cold season, CO_2 capture was captured on a period of 37 days. This was done by bubbling air on an alkaline solution of KOH. Subsequently, the carbonaceous material was extracted as graphite, and analyzed by AMS technique to determine the fraction of modern and fossil carbon in the atmosphere. Hence, the modern carbon footprint was determined by analyzing the concentration of CO_2.

The results show that the highest concentration of CO_2 and ^{14}C content coincide with the Mexican festivities: the Day of the Virgin Mary, Christmas Eve, Christmas (religious festivities) and the New Year's Eve. However, it should be noted that during the monitoring period two large fires occurred, thus the behaviour of the 14C was also analyzed on these events. The result behave as expected, because of the fireworks at Christmas Eve parties the fraction of modern carbon was increased. Additionally, an analysis of the effect of meteorology during the sampling is presented.

The use of ^{14}C as a plotter of sources opens the door to carry out new multiple studies using new methods or modifying those which have already been used for consolidating techniques to help humankind to precisely detect CO_2 emission sources. This, in order to provide useful information to policy makers so they can legislate and manage actions that reduce the emissions of this greenhouse gas in the atmosphere for the purpose of coping with climate change.

[A8] Radiocarbon analysis of atmospheric methane: new setup and first monitoring results at three Swiss sites

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Radiocarbon analysis is a promising measurement to objectively quantify anthropogenic emissions of carbon-based greenhouse gases in the current context of climate change. While natural exchange emissions of CO_2 and CH_4 contain present-day ^{14}C levels, CO_2 and CH_4 derived from fossil sources are ^{14}C-free. Radiocarbon measurements of atmospheric CO_2 and CH_4 can thus be used as a source apportionment proxy to distinct anthropogenic and biogenic CO_2 and CH_4 sources. While radiocarbon measurements of atmospheric CO_2 are already routinely measured at several sites worldwide, measurement of atmospheric CH_4 is more challenging, because CH_4 concentration in the atmosphere is about 200 times lower than CO_2.

In this context, a new methane preconcentration and purification setup was recently developed at the Laboratory for the Analysis of Radiocarbon with AMS, University of Bern (Espic et al., 2019). From about 50L atmospheric air, it allows the recovery of about 50 µg carbon, which is the quantity required for a reliable radiocarbon analysis of methane-derived CO_2 gas measurement with AMS. The main feature of the setup is the separation into a preconcentration part consisting of two charcoal traps and a purification part containing a GC. This allows the retrieval of pure atmospheric CH_4 samples that are finally oxidized in a CuO oven.
This contribution will present the new system and its performance. It will also include the results of continuous biweekly measurements started at three Swiss sites in 2018: the high altitude research station Jungfraujoch (3450 m asl), the tall tower Blosenbergturm in Beromünster (air inlet at 213 m agl) and an urban site in Bern. While most values of $\Delta^{14}CH_4$ at Jungfraujoch were measured around 350 ‰, $\Delta^{14}CH_4$ values at Bern and Beromünster showed larger scattering. Measurements in Beromünster were mostly enriched in ^{14}C due to the vicinity of nuclear power plants, not only directly in Switzerland but probably also in neighboring countries such as France or Germany; in Bern, this enrichment was partly also detectable, but measurements also revealed a depletion in ^{14}C due to local releases of fossil CH_4.
This monitoring program will be continued in the next years, especially in the framework of the new project RICH (Radiocarbon Inventories of Switzerland) aiming to develop a national radiocarbon inventory of Switzerland, not only in the atmosphere, but also in other natural compartments (i.e. soils, vegetation and water bodies).

Reference

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[A9] C-14 study in the pm10 aerosol around the Paks nuclear power plant

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Gaseous C-14 emissions are continuously monitored at the Paks NPP, while the radiocarbon content of the aerosol phase is not measured routinely. Our aim was to investigate if significant ^{14}C excess could be detected in the ambient aerosol around the Paks Nuclear Power Plant. We used Accelerator Mass Spectrometry (AMS) method to measure radiocarbon from the aerosol samples. This was the only opportunity to measure those samples which contained rather small amount of carbon (0.1-0.3 mg). We examined weekly (168h) integrated aerosol samples collected in every seasons of 2019. Samples were collected in four different directions around the power plant at four selected atmospheric stations (station A1 – A3 – A4 – A6). Waste water emission events and weeks of maintenance work were excluded from sampling campaigns. Impact of Paks NPP on the aerosol C-14 was calculated at the 3 stations (A3-A4-A6) which are more in the prevealing wind directions relative to the less exposed station A1. Seasonal and spatial variations of aerosol C-14 were investigated and compared to synchronized atmospheric gaseous CO_2 and CO_2+C_nH_m radiocarbon monitoring results.

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Keywords: nuclear power plant, aerosol, PM_{10}, radiocarbon, ^{14}C

[C1] Multi-proxy studies of the Late Glacial fluvio-aeolian succession in the type site Mierzyn, central Poland

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Multi-proxy studies (including sedimentological, pedological, radiocarbon and optically stimulated luminescence dating methods) were used to establish origin and chronology of depositional processes in the type section Mierzyn, central Poland. The investigated key site is located in the extraglacial zone of the Last Glaciation, ca. 130 km to the south from the Last Glacial Maximum in the Luciąża river valley area. In the studied profile (16 m thick) two lithofacial complexes were identified. The lower, fluvio-aeolian complex consists of silty-sandy sediments (1.6 m) deposited. The final phase of fluvio-aeolian deposition is expressed by initial pedogenic processes. Above is located aeolian complex (13 m of thickness). Three aeolian units are separated by two palaeosols.

To establish stratigraphic framework of depositional and pedogenic processes, four samples for radiocarbon dating from palaeosols and twelve samples for OSL dating from sandy units were collected. The obtained results reveal very good agreement of both absolute dating methods. It led to reconstruct chronology of main palaeoenvironmental changes. The fluvio-aeolian complex and the lowermost part of aeolian complex (below the lower palaeosol) were deposited in the Oldest Dryas in relatively cool and dry climate conditions. The amelioration of climate in the Bølling interstadial caused development of pedogenic processes expressed by 0.3 m thick palaeosol. Main part of aeolian complex (10 m of thickness) was deposited in the Older Dryas. The upper palaeosol developed in the Allerød interstadial as a result of the next amelioration of the climate. During the Younger Dryas was deposited the uppermost part of aeolian complex.

Classic development of fluvial to- aeolian succession in the Mierzyn site as well as detailed chronology based on two independent absolute age methods reveal that it can be treated as stratotype for the Late Glacial and correlated with other type sections in the Central and Western Europe.

Ackowledgments

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[C2] How detailed modelling of the biota is necessary when describing the carbon cycle?

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In the context of climate change, more and more attention is being paid to understanding the carbon cycle on the Earth. Detailed observations have been performed on regionally and temporarily varying levels of carbon dioxide in the atmosphere, as well as dissolved in the ocean. Radiocarbon, in particular its anthropogenic enhancement due to bomb tests in 1950-60s, serves as a valuable tracer of the underpinning natural processes. Numerous models have been developed to help analyse, interpret, and extrapolate the data. Classical compartmental models simplify the description of the carbon cycle by largely or completely neglecting the regional variations yet accounting for the continuous transfer of carbon between the atmosphere, ocean, soil and biota. They are computationally tractable and can be applied to simulate evolution of the system over extended periods of time. Spatially resolved models are more realistic, but also expensive in terms of computation time. They are restricted to recent periods only, in part due to the availability of the needed high-quality, high-resolution data being limited to the last few decades. In this contribution, we will present a relatively simple compartmental model that combines the classical approach by Jain et al. (1996 Tellus 48B, 583-600) with a reduced, single-box representation of the biota. The simple model correctly reflects basic observations on the carbon cycle, such as depth-dependent levels of carbon in the ocean or post-bomb kinetics of atmospheric radiocarbon. This indicates that due to short dwelling of radiocarbon in the biota compared to other compartments, its coarse modelling by even just a single box may be sufficient for some purposes.

[C3] Holocene paleoclimate reconstruction based on high-resolution peat bog chronology and stable isotope results of Sphagnum cellulose, Mohos peat bog, Romania

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This work focuses on building a high-resolution age-depth model and provides results of an isotope investigation for quantitative paleoclimate study from the Mohos peat bog, East Carpathians. A 10 m long peat core covers a period from 11,800 cal yr BP to nowadays.

The chronology was based on AMS radiocarbon analyses of the separated *Sphagnum* samples from different depths of the profile. The peat samples were wet sieved (280-40 μm) to avoid contamination by rootlets and mud. Dry *Sphagnum* samples for AMS dating were prepared using the classical acid-base-acid (ABA) method completed with an oxidative bleaching step to get clean cellulose. *Sphagnum* cellulose samples were converted to CO_2 and later graphite and measured by EnvironMICADAS accelerator mass spectrometry (AMS) in Hertelendi Laboratory (Debrecen, Hungary). The age-depth model was obtained with the use of BACON software.

A 10 m long peat core has been investigated for stable oxygen and carbon isotope analysis in form of extracted cellulose from *Sphagnum* samples. The $\delta^{18}O$ and $\delta^{13}C$ results provide us information about the past climate in the area of the Mohos peat bog. Several cooling events and warm periods had been observed and had an impact in the area of Mohos peat bog. The time series of organic matter accumulation in the Mohos peat bog have been examined parallel to the $\delta^{18}O$ and $\delta^{13}C$ reconstructed environmental parameters in order to find out the response of the peat bog to the changing environmental conditions. Overall, all shorter or longer cooling periods in the Holocene epoch occurred with a lower organic matter accumulation for a short period in the Mohos peat bog, similar consequence can be deduced with the dry periods detected in the peat core along the accumulation time series, where the drier periods can be connected to a lower accumulation rate.

[C4] Absolute chronology of the pile-dwelling constructions at Seretya II site (Western Russia) and palaeoecological context

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Results of several years archaeological research of the Serteya II site revealed the use of the area by hunter-fisher-gatherer socialites from the Mesolithic, through the Early Neolithic until the Mid- and Late Neolithic. Extremely important are the wooden constructions of Late Neolithic pile-dwellings of domestic structures, which are well-preserved within lacustrine sediment along with reach artefacts and ecofacts. The archaeological layer, at a depth from ca. 80 to ca 150 cm b.s.l. within coarse detritus gyttja, was excavated using underwater and wetland archaeological methods. Until now, six pile-dwellings, with floor remains made from large wooden bark placed on poles and wooden planks, as well as fireplaces with sand bases, were discovered. The accompanying artefacts were attributed to the Zhizhitsa Culture (ca. 2900–2000 BC). The archaeological layers are also rich in ecofacts, as: fish remains, shells of hazelnuts, water chestnuts, acorns, bones. Due to the particularly good preservation conditions, many organic artefacts made of bone and antler as well as objects of plant material could also be recovered, such as wicker baskets, nets, fish traps, and bast textiles.

The radiocarbon date set shows that these constructions could have existed between 2900 and 2000 cal. BC, while the heydays of the pile-dwelling settlement took place ca. 2470–2270 cal. BC. The archaeological and palaeoenvironmental contexts suggest that they functioned in a palaeolake shore zone with seasonal(?) water table fluctuations. The disappearance (or at least a decrease in the importance) of the pile-dwelling settlement coincided with the 4.2 ka BP cooling event, resulted in an increase of palaeolake water table.

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[C5] Multi-century stable oxygen isotope chronology from Austrian Alps

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This study presents stable oxygen isotopes research carried out for dendrochronological scale originating from the region of northern Alps. This chronology was constructed on the basis of wood derived from trees growing around the lake Schwarzensee. So far, this material was used for measurements of the growth-rings width, examinations of the latewood maximum density and investigations of the stable carbon isotope content within individual growth-rings.

The main objective of the study was to develop an oxygen stable isotope chronology to be employed in the next phase of the ongoing works aimed at climate reconstruction in the area of Schwarzensee Lake. The research undertaken here is complementary especially to former stable carbon isotope analyses, because it provides a better understanding of relationships that occur between environmental factors affecting tree growth and physiological processes taking place in plants as a response to the impact of external conditions which finally manifest themselves in the stable isotope composition of wood. Recognition of these interactions is, in turn, essential for the correct interpretation of the measurement's results.

For isotopic studies, modern and subfossil wood was used. Subfossil wood excavated from the bottom of Lake Schwarzensee, came from trees growing on hills extending around the lake. These trees were fallen down by wind or snow, slid down the steep slopes and their trunks were deposited at the bottom of the lake. Due to the limited availability of oxygen, the stems persisted in water environment in a very good preservation state. Also the contemporary wood was bored from trees living in the nearest neighbourhood of the lake. The most abundant species among the subfossil samples, i.e. Norway spruce (*Picea abies* (L.) Karst.) was selected for dendroclimatic research.

Isotopic analyses were carried out for 51 subfossil samples and 5 samples of modern wood. Individual growth-rings were separated, fragmented, and for each year, material from four trees was averaged in equal ratios of weight. Next, the α-cellulose was extracted from consecutive annual growth-rings. These growth-rings were prepared as a whole, without segregation into earlywood and latewood zones. During isotopic measurements an IsoPrime EA-CF-IRMS mass spectrometer coupled with a EuroVector elemental analyser was utilised. Average measurement data were applied directly to isotopic chronology development.

As an effect of the conducted research a multi-century chronology of stable oxygen isotopes covering the years 800–2000 CE was built. This chronology was compared with meteorological data from weather stations located in a close vicinity of Lake Schwarzensee. For this purpose correlation coefficients for particular months were calculated over the period 1780–2000 CE. These computations were conducted with the program DENDROCLIM 2002.

It was observed that the isotope content measured within the subsequent growth-rings corresponded well with the temperature of the summer months. The best fit between the temperature and the stable isotope ratio was obtained for July–August months, and in a broader range, for the May–September season. In the May–September period correlations were statistically significant and linear correlation coefficient amounted to 0.466. The results for respective month were also relevant: May–0.213, June–0.163, July–0.498, August–0.288, September–0.155.

The outcomes obtained here indicate that climatic factors – especially the temperature of the vegetation period (May–September) – exerted a strong influence on the stable oxygen isotope ratio which has been recorded in successive annual growth-rings. As a consequence, the new chronology successfully reflects the weather conditions that existed during the life span of the trees. This, in turn, makes it possible to precisely reconstruct the thermal conditions of the studied region over a time span of 1200 years.

[C6] Temporal stability of climatic signal recorded by carbon, oxygen and hydrogen stable isotopes of tree rings cellulose – case study for Suwałki region

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Tree rings, because of their prevalence and the relative ease of dating, seem to be an excellent archive of past climatic and environmental change. Tree growth, photosynthesis, and isotope fractionation is influenced by defined climatic conditions like temperature, precipitation, humidity, light intensity and change in soil moisture. Isotopic measurements in tree rings can be very useful in reconstructing past climate. However, such reconstructions may encounter some problems. One of these, especially at the present time, is environmental change caused by anthropopression, which also affects the stable isotope ratios. Since the beginning of industrial revolution, the $\delta^{13}C$ of the atmospheric CO_2 has decreased due to emission of ^{13}C-depleted CO_2 from human activities such as fossil fuels burning and land clearing. The so called Suess effect is reflected in tree rings $\delta^{13}C$. Emissions of SO_2, NO_x, and other phytotoxic compounds lead to serious disturbances in tree physiology and metabolism and therefore change also isotopic composition of plant tissue. For example, gaseous SO2 can cause the closure of stomata and reduce negative carbon isotope composition. It can also affect oxygen isotope composition.
The research area is situated not far from Suwalki city (54°06 'N, 22°57'E) in the North-Eastern part of Poland close to the Polish - Lithuanian border. The city and the region have valuable forest complexes and areas relatively unchanged by human activity. Testing the temporal stability of climate - stable isotopes relationships have fundamental implications not only for reconstruction of natural climate variability, but also for estimating changes associated with anthropogenic activity. Relationships between isotope values and monthly climate data were modelled using bootstrapped correlation function in DendroClim2002. Values of $\delta^{13}C$, $\delta^{18}O$ and $\delta^{2}H$ in tree ring cellulose strongly respond to current year temperature, insolation, relative humidity and precipitation. Using a moving interval technique, the temporal stability of correlation between isotope chronology and climate was investigated. These studies showed no climate signal stability for the years of the maximum industrial human activities.

This work is a part of a EU ISONET project No. EVK2-CT-2002-0014 (400 years of Annual Reconstructions of European Climate Variability using a High Resolution Isotopic Network).

[C7] Impact of climatic and anthropogenic factors on the composition of stable carbon isotopes in tree rings cellulose - a case study for the Sudeten, Tatras and Eastern Carpathians

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Tree rings provide a valuable information of past climate and environment. Human activities have altered atmospheric composition and climate. It has implications for plants physiology and physical response.

Results concern measurements of $d^{13}C$ in cellulose extracted from tree rings for mountain regions will be presented. The selected research areas: Sudeten, Tatras and Eastern Carpathians represent mountains regions with various intensification of anthropopression. Carbon isotopic composition of α-cellulose samples was determined using the continuous flow isotope ratio mass spectrometer coupled to the elemental analyser.

Analysis of stable carbon isotope ratios in annual increments allowed the relationship between $d^{13}C$ and temperature and precipitation to be established. Tests of the temporal stability of the climate signal showed that it is much weaker for the period of increased human activity. Carbon isotopic composition ($\delta^{13}C$) were 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). The $^{13}C/^{12}C$ ratio in trees is controlled at the leaf level by the ratio of intercellular (C_i) to ambient (C_a) CO_2 concentrations. If C_i is high relative to C_a, strong discrimination against ^{13}C yields isotopically light biomass. Conversely, if C_i is low - discrimination against ^{13}C results in higher $\delta^{13}C$ values. Therefore, any change in carboxylation and/or stomatal conductance that altered ratio C_i/C_a is recorded as a change in $\delta^{13}C$. Variations in atmospheric $\delta^{13}C$ should be taken into consideration and $\delta^{13}C$ in tree rings must be analysed in relation to atmospheric $\delta^{13}C$ at the moment of its assimilation. Numerous studies have reported widespread increases in iWUE coinciding with rising atmospheric CO_2 concentration over the past century. Investigations for mountain regions confirm that the intrinsic water use efficiency of trees (the ratio between carbon uptake and water loss through transpiration) increases as stomatal conductance decreases in response to elevated CO_2. Differences in iWUE, calculated from data sets, representing three mountain regions are signifficant. This is connected with different degrees of pollution emissions and different climatic conditions affecting process of photosynthesis.

This research was a part of projects: "Trees as isotope archives of climate and human impact on environment in Central Europe Mountain areas" funded by the National Science Centre allocated on the basis of decision number 1557B/P01/2009/37

[C8] Record of the climatic conditions variability during the Holocene in the stable Carbon and Nitrogen isotopes (a case study of Pacynka river valley)

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The two-meter core of organic and mineral sediments filling the wide, pool section in the Pacynka river valley near Radom was tested for the differentiation of the physicochemical properties of the sediments filling it. The samples for analysis were taken every 2 or 4 cm depending on the texture of the sediments. Basic physicochemical analyzes (organic matter and calcium carbonate contents, magnetic susceptibility or chemical composition of sediments) and isotopic composition (δC, δN) were performed. Six radiocarbon datings were made, which were arranged in a superposition. Although the sediments accumulated in river valleys (in this case the basin section of the valley bottom) are not as good an environmental archive as lakes, very interesting results were obtained from these studies. The variability of the analyzed features of the sediments corresponds very well with the Holocene changes in the natural environment - the changes recorded in the stable isotopes are a proxy reflecting the climatic conditions (cold-warm, dry-wet), while the variability of the magnetic susceptibility and the content of heavy metals in the sediments represent progressing anthropopressure.

[M1] The history of the brown bear *Ursus arctos* Linnaeus, 1758 in the Czech Republic

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The find from Chlum 4 (800-700 kyr) is the oldest Czech record of *Ursus arctos* or at least form of arctoid lineage (Wagner and Čermák, 2012). The Eemian (MIS 5e) is the time when undoubtedly true brown bears appeared in the Czech territory (Mostecký 1963, 1969, Wagner 2001, Musil 2018). In the Late Pleistocene, 55 sites documented its presence within the Czech territory (Wagner 2001, Musil 2018, Marciszak et al. unp.). The time distribution shows the more or less continuous persistence of this species during the last 14 kyr. The first part of MIS 1 (13.5-8.0 kyr BP) are documented by paleontological sites, while the material younger than 8.0 kyr BP came mostly from archaeological localities. After the Neolithic Agricultural Revolution (ca. 6-5.5 kyr BP), human impact still grew, but the brown bear still found suitable habitats and lived in relatively high density. It is present in all archaeological cultures (Kyselý 2005). *Ursus arctos* was one of the most abundant species among wild carnivores in archaeological assemblages.

In the Czech Republic the situation started to change considerably 600-500 yr. More or less compact so far range of occurrence in the Czech territory split into local and mutually separated populations, which areas were still reducing during time. The bear density and number was especially strongly restricted in lowlands, and human pressure pushed the species into mountains areas. Historical sources (Vodák 1993) confirmed presence of the species in hills in vicinity of Prague 400-350 yr. It is not excluded that some small, relict, populations still survived to this time also in other areas, but is already regarded as a rare faunal element and finally disappeared from the Czech lowlands about 350-330 yr (Červený et al. 2004).

Between 350-250 yr the process of extermination of *U. arctos* continued, finally resulting in disappearance even from the refuges in peripheral ranges of mountains. Till 1750's the brown bear was extinct in Novohradské Mts. and Krkonoše Mts. Single records of killing on lowlands from this time are considered as roaming/migrating animals (Andreska 2012a, 2012b). After 1770 bear as a resident species survived only in Šumava Mts. and Bavarian Forest Mts on the west and Beskydy Mts on the east, but also here he was under strong pressure. It resulted in vanishing also here, with the last female being shot on 4.11.1856 by Jelení vrchy village (Vodák 1993). It is considered to be the last sure/confirmed presence of

brown bear in the Šumava Mts. The presence of the migrated individuals was noted however till the end of 1890's (Červený et al. 2004). Interesting archaeological find comes from Chanovice near Šumava, which is dated to this period and which can represent one of the latest Czech bears (Sůvová 2014). In Beskydy Mts. the species was able to survive longer due to the connection with the Slovak population, but also here the last individuals were hunted 120-110 yr (Jakubiec 2001).

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[M2] Investigating Pattern Matching Techniques for the Calibration of Radiocarbon Measurements

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Sudden annual rises in radiocarbon concentration, or Miyake Events, have proven to be valuable assets for achieving exact-year calibration of radiocarbon measurements. These extremely precise calibrations have usually been performed through the use of classical X^2 tests in conjuncton with a local calibration curve of single-year resolution. As the new version of the Northern Hemisphere calibration curve, IntCal20, exhibits single-year resolution over the last 2000 years, in this study we investigate the possibility of achieving exact-year dating more extensively. We examine scenarios with and without the aid of abrupt Miyake-like changes in radiocarbon concentration. In order to perform a broad analysis, we simulated 180 sets of radiocarbon measurements over the last two millennia, with different set lengths and sample spacings, and tested the effectiveness of the X^2 test compared to the most commonly used wiggle-matching technique, the OxCal D_Sequence, and to another statistical technique, Dynamic Time Warping. Unfortunately the latter showed inconsistent results, and has therefore been excluded as a viable candidate. The D_Sequence tends to always produce a date range, albeit often very short; however, the X^2 test shows good potential for the achievement of exact-year dates in many different scenarios

[M3] Development in AMS graphitization line in Dendrochronological laboratory at AGH-UST Krakow

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Accelerator mass spectrometry (AMS) technique is the most common technique used in radiocarbon dating. The procedure of age determination with this technique is divided into two parts, sample preparation and measurement. Sample preparation includes mechanical and chemical processes of cleaning, combustion, graphitization and pressing into sample holder.

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. This system consists of equipment for mechanical and chemical sample pre-treatment, vacuum line for sample sealing and purification of CO_2, and graphitization line, where occurs reduction of CO_2 on iron powder. 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.

[M4] ^{14}C origins and speciation within a nuclearized continental catchment : State of the art and outlook

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^{14}C or radiocarbon is a radioactive isotope of carbon with an abundance of less than 0.01% [1]. It has natural but also anthropogenic origins from nuclear installation discharges into the atmosphere and the aquatic environment [2]. In streams, the understanding of ^{14}C discharges from industries and its transfers in ecosystems remains complex. As an example, excess ^{14}C concentrations referring to expected levels from modelling were recorded in fishes downstream the Loire and Rhône Rivers (i.e. nuclearized rivers) [3].

The thesis aims to define the fundamental aspects of radiocarbon speciation in the Rhône River and to better assess the anthropogenic marking levels of the environment by chronical or accidental discharges from nuclear industries.

In hydrosystems, ^{14}C is distributed among four C phases: dissolved (i.e. aqueous phase) and particular phases (i.e. suspended matter). Both are composed of an inorganic phase, characterized by mineral compounds (DIC / PIC), and an organic phase, represented by organic compounds (DOC/POC). A wide diversity of physical, chemical and biological mechanisms govern the exchanges between these four C guises [4,5]. After a state of the art on the environmental dynamics of ^{14}C, we focus on the Rhône catchment showing a large range of lithology and hydrodynamic conditions [6]. In addition, this watershed holds several nuclear facilities allowed to release ^{14}C in the river [7].

The project will be based on fieldwork sampling and monitoring including data sets from national observatory (SORA-MOOSE) and OSR (Observatoire des Sédiments du Rhône).

A temporal approach will firstly be implemented. High-frequency acquisitions of environmental data will be performed (i.e. water discharge, suspended matter concentration, conductivity and chlorophyll a contents) on three instrumented sites: outlet station (SORA-Arles), Ardèche River, a tributary of Cévennes, and Durance river, an alpine tributary enriched in fossil organic carbon which play a significant role in ^{14}C dilution downstream the confluence [2].

Water and sediment sampling campaigns will start on March 2020 and complete the dataset. The ^{14}C signatures will be measured in the four studied phases ($DI^{14}C$, $DO^{14}C$, $PI^{14}C$ and $PO^{14}C$). Relationships between environmental data and radiocarbon signatures will be established in order to study involved mechanisms on ^{14}C speciation. Then, ^{14}C fluxes for each phase will be calculated to identify the role of both tributaries on ^{14}C speciation in the Rhône River. A Monte-Carlo simulation could be set up to strengthen relationship taking into account measurement uncertainties [8].

A spatial approach will secondly implemented and will consist in water sampling throughout Rhône tributaries. Mixing diagrams would be a final sketch to distinguish tributary and nuclear facility contributions on ^{14}C concentrations at Arles (outlet).

Acknowledgments

The acquisition of environmental data will be performed in partnership with the 'Morphodynamique Continentale et Côtière' laboratories (Rouen-Normandie University) and the Mediterranean Institute of Oceanography (Aix-Marseille University).

Radiocarbon measurements will be realised at 'Le Laboratoire des Sciences et du Climat et de l'Environnement' (Versailles Saint-Quentin University), the 'Laboratoire de Mesure du Carbone 14' (Paris Saclay University) and Atomki laboratories (Debrecen-Hungary).

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[M5] Sealed tube graphitization method at LMC14, Gif sur Yvette (France) for environmental ^{14}C monitoring

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The Laboratoire de Mesure du Carbone 14 (LMC14) operates since 2003 the ARTEMIS facility, an Accelerator Mass Spectrometer (NEC 3MV Pelletron) dedicated to the measurement of carbon 14 in natural samples for various studies in the fields of environmental sciences and cultural heritage. Organic and carbonated materials are fully prepared before measurement through the three usual preparation steps : mechanical and chemical cleaning, extraction of CO_2 and graphitization (Dumoulin et al., 2017, Moreau et al., 2013). The graphitization procedure is based on the Fe catalyzed/H_2 reduction of CO_2 described by Vogel et al. (1984) and is operated on two semi-automated rigs.

Batches of natural samples collected for environmental ^{14}C monitoring purposes are regularly submitted to the LMC14 for preparation and measurement. The carbon 14 activity of these samples is generally in the range of modern to not more than 5 times modern. To operate quickly these samples and to avoid cross contaminations with the "old" samples also prepared in the laboratory, it was decided to build a new dedicated preparation line.

This line allows the combustion of the samples via an Elemental Analyzer (Flash 2000 - ThermoElectron) and the transfer of the CO_2 produced in sealed tubes filled with Zn and TiH_2 reactants. The whole set up is partly automatized thanks to a homemade software written in LabView.

To validate this new preparation line, several tests were performed to improve the efficiency of solid carbon production in our sealed tubes facility, the ^{14}C background level, the accuracy and reproducibility of the process. Raman analysis was also used to characterize and compare the quality of solid carbon obtained by sealed tube method and Fe catalyzed/H_2 reduction method. We will present the results of these tests realized on ^{14}C reference samples and blanks.

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[M6] Human presence in the Salapunku area (Cusco, Peru) based on recent radiocarbon evidence

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The Salapunku archaeological site is located within the Machupicchu National Archaeological Park in the Cusco area of Peru. Although Salapunku is located in the area of the Inca-related Machupicchu, within the archaeological site during the archaeological work it was possible to distinguish different moments of multicultural occupation. The Inca occupation phase is the most recent use of the site, but in earlier periods there were human settlements in this area associated with the Killke culture and even with human presence during the local formative period. Previous research on the chronology of the site was based on typological analyses of pottery and other artefacts found during excavations. With research extended by radiocarbon analyses, it has been possible to establish a chronology of settlement development in this part of the Park considered to be the gateway to the Cordillera of Vilcabamba. The purpose of this presentation is to show the recent findings of human presence in this area and its possible relation to climate/environment changes.

[M7] Very small samples and sample representativeness: statistical approach and real example. What can be done to make the measurement representative of the sample natural heterogeneity?

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Recent technological developments have made it possible to reduce the size of the samples and to open up new fields. This is particularly the case for MICADAS (Synal et al. 2007). They offer the possibility of making measurements that could be called "classic", on 1 mg of carbon but also on quantities as small as a few tens of micrograms of carbon. These measurements are then carried out via the GIS interface coupled to an elemental analyzer (EA-GIS coupling - Ruff et al. 2010). They are accessible to all samples whose carbon content allows to extract these few tens of micrograms of carbon from a few tens of milligrams of raw sample (volume limitation of the capsule to be introduced in the EA).

For some highly heterogeneous sample, such as soil, working on a few tens of micrograms of carbon does not allow to reach, to encompass, the sample heterogeneity. The analytical error is therefore far from representative of the sample natural variability, and the measured value may even be far from the true sample mean. Measuring only one aliquot and considering the analytical error as the sample standard deviation can therefore lead to erroneous interpretations.

We show here, on a simple statistical basis, the implication of the test sample on the measurement representativeness (mean, median, error). The findings and recommendations we draw, are then analyzed in relation to real results obtained on soil.

Our findings aren't restricted to ^{14}C and to soil and can be generalized to any geochemical analysis.

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[M8] The new sample preparation line for radiocarbon measurements at the GXNU Laboratory

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A new system for preparing ^{14}C sample with various methods, the zinc method, hydrogen method, and titanium hydride method, was established for the small accelerator mass spectrometer (GXNU-AMS) at Guangxi Normal University, This sample preparation system is consisted of three units: vacuum maintenance unit, CO^2 purification unit and CO^2 reduction unit, all of the main structure is made of quartz glass. A series of 14C preparation experiment was carried out to verify the reliability of the system. The recovery rates of graphite obtained were more than 80%. The carbon content in the commercial toner and wood sample was linearly fitted to the CO2 pressure in the measurement unit of the system. The results showed an obvious linear relationship, indicating that the reliability of the sample preparation system can meet the requirements of ^{14}C-AMS. A batch of standard samples, wood samples and dead graphite samples made by this system were performed with AMS measurement . The results showed that the beam current of ^{12}C- for each sample was greater than 40uA,which could meet requirement of AMS measurement. The measurement results of blank samples indicate the stability of the sample preparation system and the carbon pollution introduced during the sample preparation process was less than 2×10^{-15}. The results show that the new sample preparation system established is a compact, low-pollution, and efficient system, which meet the GXNU-AMS requirements for ^{14}C samples.

[M9] Search for the potential 14C excursions in the Intcal/SHcal curves and data raw atmospheric ^{14}C time series

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Accuracy of radiocarbon dating depends both on uncertainty of radiocarbon concentration/radioactivity determination in a sample and quality of radiocarbon calibration curve. Radiocarbon calibration curves are sophisticated compositions of time series coming from different carbon reservoirs/environment. Time resolution of the Intcal20 and SHcal20 vary from one year to couples of ten years for different time periods. Precise radiocarbon dating, especially incorporating so-called wiggle matching approach requires high-resolution calibration curve. Miyake discovery of rapid ^{14}C excursions in last millennia made obvious necessity of intensifying efforts to identify all the parts of calibration curve which may contain information about similar excursions. The identification should lead to the discoveries of other periods containing Miyake effect excursions, which will probably result in increased radiocarbon dating accuracy for time periods covering Miyake effects. Here we present results of automatic search for Miyake effect excursions in the all atmospheric ^{14}C time series used for Intcal and SHcal 2020 construction. We also propose a simple method of calibration curves analysis in order to find time periods suspected to contain hidden information about excursions.

[M10] Problems of isotopic fractionation correction in ^{14}C applications

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Industrial applications of radiocarbon radioactivity determination require taking into account isotopic fractionation correction. The correction should cover changes of ^{14}C concentration during carbon transfer from atmospheric CO_2 to the medium where $^{14}C/^{12}C$ ratio is determined. The medium may be graphite or CO_2 in AMS/PIMS method, CO_2, CH_4, C_6H_6 in case of liquid scintillation spectrometry or gas proportional counting. Almost all the steps in the process of transfer of carbon atoms from atmospheric 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 describe use of radiocarbon method for determination of bio-component share in commercial products. The fractionation correction for ^{14}C is based on $\delta^{13}C$ measurements in a counting medium and assumption of constant differences in $^{14}C/^{12}C$ and $^{13}C/^{12}C$ fractionation. It has been shown by several authors that the latter is not well known. In this poster I will demonstrate that even when assuming known and constant differences in $^{14}C/^{12}C$ and $^{13}C/^{12}C$ 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}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.

[M11] Radiocarbon calibration curves mixing and its influence on the chronology of Machupicchu and satellite settlements

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The chronology of Machupicchu was traditionally associated with the period attributed to the reign of Pachacuti Inca Yupanqui. Within the scheme on the so-called historical chronology, proposed by John H. Rowe in 1945, the ascension to power of Pachacuti Inca took place around 1438 AD and the construction of Machupicchu began by 1450 - 1460 AD. There are several radiocarbon-dated samples that may help to try to understand the chronology of the construction of llaqta of Machupicchu, Chachabamba, and Choqesuysuy. The sites have been interpreted as being part of the contemporary Late Horizon Inca landscape. However, all the sites are located in the Andes where the influence of the Northern and Southern Hemisphere for the atmospheric radiocarbon radioactivity is to be investigated and discussed for different periods. The influence will probably reflect both regional and global climatic changes in the region. Here we present how different mixing of Intcal13/SHcal13 and Intcal20/SHcal20 radiocarbon calibration curves influences the chronology of all three sites.

[M12] Testing the methods for determination of biocomponent contents in liquid fuels in the Gliwice Radiocarbon and Mass Spectrometry Laboratory

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Keywords: Liquid fuels, Biocomponents, Radiocarbon, Carbon Isotopes, AMS, LSC

Radiocarbon is one of the most widespread cosmogenic radionuclides in nature. Even though, it is probably best known for dating in archaeology, radiocarbon radioisotope (^{14}C) is being used in measuring the content of biocomponents in various materials. This represents a useful tracer to study our environmental changes, both in the past and nowadays. The aim of this work is to test and verify the methodology of determining the content of biocomponents in liquid fuels in the Gliwice Radiocarbon and Mass Spectrometry Laboratory.

The determination of biocomponents from liquid fuels' samples using radiocarbon radioisotope (^{14}C) method is being investigated by liquid scintillation counting (LSC) and accelerator mass spectrometry (AMS) to adapt the methods for sample preparation and measurements to the conditions in our Laboratory. The samples are prepared using tin capsules for liquids for combustion in EA and graphitisation. For LSC method the liquid fuels will be prepared after mixing with purified pre-heated sand using a benzene synthesis line.

The obtained results from different measurements will be supported by stable carbon IRMS analysis, aimed at verification of the isotope fractionation occurring during the preparation and measurement processes.

Based on isotopes studies, the biocarbon contents in liquids fuels will be calculated. In addition, this study supports the evaluation of the accuracy of investigated methods for quantifying the biocomponents in liquid fuels. The present work is also a move towards the accreditation of the tested methods in the Radiocarbon and Mass Spectrometry Laboratory.

[M13] Tests for the content of the ^{14}C isotope in tires and their pyrolysis products

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Worldwide the number of vehicles is increasing and resulting in a growing amount of end of life tires. Waste of tires is wasting valuable material like rubber/plastic blends and enhancing the environmental and land pollution. Waste tires are considered to be a source of valuable materials which can be used to produce new products of valuable significance. The European Union tires recycling rates are close to 100% to overcome the landfill complications [Sebola et al. 2018, Luo et al. 1998]. Increasing emphasis on environmental and sustainability, the recycling of waste is favored action way for many waste streams. Pyrolysis is a recycling technology. Pyrolysis of tires produces oil, black carbon and gas products, all of which are the perfect source of energy and also useful for many purposes [Williams & Brindle 2003]. Tires contain about 60-70% carbon content. Their combustion and composition properties are almost comparable or even better than coal and also reduces CO_2 and SO_x in the atmosphere [Rodríguez et al. 2017]. The tires are used as fuels and reduce the consumption of traditional fuels and energy bills, they also provide heat but help control the emission of CO_2 [Krajcar Bronić et al. 2015].

The research work was created in cooperation with CONTEC Ltd. that deals with tire pyrolysis [de Marco Rodriguez et al. 2001]. The subsequent stages of the technological process can be described as follows:

in its first stage, cord and steel wire are separated from the tires;

in the mechanical grinding process, different sizes of rubber particles are obtained: rubber dust, finely ground rubber, granules or grits;

the raw material prepared in this way goes to the reactor via a feeder. In order to remove air from the feeder, the load is purged with nitrogen at the end of the feeder;

in the reactor, having the shape of a horizontal, stationary cylinder, heated by a heating medium (a mixture of molten salts) with an auger, an anaerobic, low-pressure, low-temperature hydrocarbon decomposition process takes place. The temperature of the reactor is kept at 500 °C;

a special system collects the recovered carbon black (rCB) from the reactor outlet. The CB temperature is lowered through the receiving conveyor cooling jacket;

at the carbon black processing station, the material is subjected to magnetic separation with the yield of steel in the amount of up to approx. 4% of the total weight of the wire;

pyrolytic gas collected separately from each section of the reactor is directed to the process gas separation node. The fuel gas produced from the non-condensing part of the pyrolysis gas is burned and the heat used in the process.

The aim of our research was to examine the content of the ^{14}C isotope in rubber obtained from grinding tires and in pyrolysis products - i.e. carbon black and pyrolysis oil. As part of the poster, the results of measurements of the concentration of the ^{14}C isotope made with the use of the LSC and AMS techniques at the Radiocarbon Laboratory in Gliwice [Pazdur et al. 2003, Piotrowska 2013].will be presented. Tests of the variability of the ^{14}C concentration within one batch of tires will also be presented, as well as between batches and the results of the study of differences in the content of the ^{14}C isotope in passenger and truck tires.

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[M14] Intercomparision exercise on fuel samples for determination of biocontent ratio by ^{14}C Accelerator Mass Spectrometry

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The method of biobased carbon content determination in liquid fuel samples has been standardized, but different laboratories use different protocols during the preparation and performance of the measurements with different machines. The accelerator mass spectrometry laboratories use different combustion, preparation and graphitisation methods for the graphite production for the spectrometric measurements. As a results, the intercomparison between the laboratories is necessary, to demonstrate precision and accuracy, and for the demonstration that the results are comparable. In this study, we present the results of an intercomparison campaign involving three European 14C accelerator mass spectrometry laboratories. Five samples were used in the measurement campaign, two biocomponent (fatty acid methyl ester, hydrotreated vegetable oil), one fossil component (fossil diesel) and two blends (mixtures of fossil and biocomponent with 90-10% mixing ratio) in the laboratory of CEDAD (Italy), ETHZ (Switzerland) and Isotoptech-ATOMKI (Hungary). The calculated $^{14}C/^{12}C$ ratio (pMC) and biobased carbon content results are in a good agreement between the three laboratories and the real, actual biobased content of the distributed samples. All of the laboratories could determine the biobased carbon content within 1 %, which shows that the applied methods can meet the most expectations even at the industrial field. The precision and accuracy of the presented results are similar to those found in the literature (Bronić et al. 2017a; Haverly et al. 2019b; Oinonen et al. 2010; Varga et al. 2018).

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[M15] Development of protocols for measuring anthropogenic radiocarbon in environmental studies on ECHoMICADAS at LSCE, Gif-sur-Yvette

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^{14}C in the environment is generally used as a tracer to identify sources of carbon in various samples (airborne, water, soil, organic matter…), in order to study mechanisms and processes of carbon cycle. It is derived from 3 main sources: natural production, anthropogenic production due to atmospheric testing of nuclear weapons and releases associated with nuclear activities. Measuring environmental and non-environmental active samples must be done with extreme care in order to reduce the risk of contamination of laboratory materials.

A possible method consists of diluting the active sample by adding a blank (material without ^{14}C). At LSCE, we have developed two different protocols according to the sample type. The first one, which consist of mixing two samples of known quantity of CO_2, previously used for small size samples measurement [1], has been used for active gas samples. The second one is adapted for sample fractions under solid form. The sample is first weighed into a tin capsule into which a known amount of "blank" (phthalic acid) is added. Dilution is performed during combustion in an elemental analyser (EA). Tests have been done using the Ionplus AGE3 graphitisation system or the gas interface system [2,3], by measuring different NIST OX-2 standard dilutions, giving a reproducibility of around 1.5% and some real samples. Results will be discussed regarding advantage of such a solution, and its limits.

[1] M de Rooij et al, 2008; [2] Wacker et al., 2010; [3] Wacker et al., 2013.

[M16] Chronology of striated pottery in the eastern Baltic: a case study of river Daugava settlements

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Striated pottery is one of the most characteristic artefact groups in Late Bronze Age (1100 - 500 BC) eastern Baltic. It is considered as one of the "key artefacts" for determining an overall chronological framework of the archaeological site. However the detailed studies of chronology of emergence, change of techno-stylistics and in the end disappearance of striated pottery tradition in eastern Baltic has been neglected. The aim of this paper is to determine a more precise chronological framework of emergence, change and disappearance of striated pottery tradition in settlements near river Daugava which can be assumed as one of the most densely inhabited rivers in the eastern Baltic with active trade and exchange system. For this study pottery crust from eight sites has been analysed using ^{14}C AMS - three open rural settlements - Vampenieši, Laukskola and Kerkūzi I settlements and five hillforts - Vīnakalns, Dievukalns, Mūkukalns, Spietiņi and Asote.

[M17] High-resolution radiocarbon dating of ivory

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International trade in ivory from African elephants is, with some minor exceptions, possible only in antics older than 1947. Therefore, the determination of the age of the ivory is a crucial aspect in the fight against illegal ivory trade. Radiocarbon dating has a great potential in this field. The method exploits temporarily enhanced radiocarbon levels in the environment due to nuclear weapon testing. The resulting radiocarbon spike, reflected on the calibration curves as so-called bomb peak, enables age determination of the relevant samples with high-resolution, in terms of units of years. This advantage is fading now, as the radiocarbon level reaches the value before the nuclear tests, therefore there is a demand to combine radiocarbon dating with further methods to keep possibility of high-resolution age determination. This work explores how the ivory tusk grows and its dependence on several factors, such as natural population or captive breeding. We present results of radiocarbon analysis for the ivory tusks sampled through different their depths as well as lengths. Wiggle Matching analysis of radiocarbon activities enables to track accurate tusk chronology, suppressing the ambiguity of dating result and precising the time intervals.

[M18] Problems in the dating of slope sediments; case study in Serteyka River Valley (Eastern Europe)

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The accumulation fan was developed at the mouth of a well-developed system of erosive cuts in the Serteyka River valley. Inorganic sediments of the fan covered biogenic lacustrine deposits (mostly gyttja and peat). The beginning of the development of the form was determined by radiocarbon dating at the earliest in the second half of the 17th century AD, which constitute a record of palaeoenvironmental changes during the pessary of the Little Ice Age (LIA).To determine the phases of the accumulative fan development, various methods were undertaken: radiocarbon dating with the AMS method based on plant macrofossils, as well as OSL and ^{210}Pb dating of sandy sediments. Dating using OSL and Pb^{210} methods encountered several difficulties during the absolute age determination process and in the interpretation of the results. The results OSL dating are not consistent with the AMS dating. An important element of the research was sedimentological analysis indicating the processes of formation of defined geological units, which resulted in explaining the discrepancy between the obtained AMS and OSL dates. Additionally, an age-depth model was made using various types of date sets. The possible redeposition during slope processes of plant macrofossil (used for AMS dating) and sandy material (OSL), as well as mixing sediments during plowing (^{210}Pb),had to be taken into account when interpreting the results.

[T1] Abrupt increase of radiocarbon concentration in 993 CE in sub-annual tree rings from Kujawy near Cracow (SE Poland)

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

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[T2] Characteristics of Pine Needle Exposed to the Air Pollution Sources in Silesia – a case study

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Human activities connected with the emission of different pollutants to the atmosphere affect the physiological processes that control tree growth. The determination of tree-ring and foliage properties is crucial in the investigation of local and global environmental changes. Trees analysis and the determination of the chemical composition of the foliage are useful in ecosystem biomonitoring, in particular when assessing the impacts of soil, air, and water pollution. The results reflect a mix between different anthropogenic sources. We present the results of the analysis of radiocarbon composition of tree needles and the results of the analysis of the components deposited on the surface of the foliage. The samples were collected in the forests located in the most industrialized part of Poland - Silesia, where coal mining and coal-based energy are an important branch of industry. The radiocarbon analysis was performed by usingβ-radiation liquid spectrometer of the Quantulus 1220 type and the analysis of the surface of the needles and the component deposited on the foliage was performed by using Phenom PRO X (Thermo Fisher Scientific) scanning electron microscope (SEM) equipped with an EDS analyzer. The spatial-temporal differences in physico-chemical characteristics of pine needle have been observed in the investigated area.

The research was a part of the Project Based Learning: "Applied Physics and ArcGIS technology in the Environmental Research: Air pollutants accumulation in the foliage - a case study of biomonitoring of the industrial area (DEPON)" (PI: Barbara Sensuła, Team Leader: Agnieszka Sasiela). We would like to tkank to Marzena Kłusek and Barbara Benisiewicz for technical support in samples preparation.

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[T3] Anthropogenic pollution records in pine tree-rings: radiocarbon, stable isotopes and Basal Area Increment analysis- a case study

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The main aim of the study was to analyze the variability of Basal Area Increment (BAI) as well as content of stable isotopes and radiocarbon in *Pinus sylvestris* L. tree rings. Analysed Scots pines grew on the fresh mixed coniferous forest habitat type on site located in highly urbanizated and populated area in Silesia. The combined usage of tree ring width and isotopic data allowed to identify how investigated trees have adapted to the pollution. We observed depletion rates of carbon isotopes (C-14 and C-13) concentration in alpha-cellulose related to the CO_2 emission into the atmosphere in the processes associated with the fossil fuels combustion. Prior to 2000, a decrease in stomatal conductivity was associated with a minor changes in the net photosynthesis rate and that elevated CO_2 increased intrinsic water use efficiency (approximately by 40%). Industrial pollution weakens the vitality of trees and their growth potential and their sensitivity to the meteorological factors, which results in an increase in the heterogeneity of their annual incremental responses and a weakening of the climatic signal contained in their BAI chronologies. The analysis of changes in the size of the basal area increment (BAI) of pine wood showed that in the years 1960-1980 there was a clear long-term decrease in the size of the wood increment of the examined pines. It is the period of the culmination of the emission of industrial pollutants in Silesia. In these years, the annual variability of BAI decreased significantly, which is the result of the pressure of weather conditions changing from year to year. The rbt and SNR index also decreased. The lowest values of the rbt and SNR indicators were found in the period 1965-1994. In the 1980s and at the beginning of the 1990s, after the reduction of pollutant emissions by industry, all the above indicators increased. The examined pines began to increase the growth of wood again, the annual variability and homogeneity of the incremental reactions increased, as well as the strength of the climatic signal contained in their chronologies.

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Combined Heat and Power Plant During the Development of the Pro-Ecological Strategy in Poland. *Water Air Soil Pollut* 226, 220

[T4] Complex study of the Miyake effect and reconstruction of paleoclimate changes during VIII-VII century BC, based on AMS and MS measurements in subfossil wood from Poland

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Miyake was the first to describe rapid and shortlasting increases of radiocarbon (^{14}C) concentration in the annual tree rings between AD 774 and 775 and AD 993 and 994. This sudden increase of radiocarbon has been confirmed also by other scientists. Similar study has been conducted in Poland at the AGH University of Science and Technology and Silesian University of Technology. The results clearly show a rapid increase of ^{14}C concentration in these years. Results of last studies confirmed that the abrupt increase in ^{14}C concentration is also visible between 663 and 662 BC.

An innovative element is detailed AMS ^{14}C measurements of samples from two more tree rings with the Miyake effect and three before and after Miyake effect. Each of these tree rings was divided into 2 parts, one of early wood and one of late wood. This samples give information on the speed of content change ^{14}C during the growing season and thus indicate whether the beginning of this event took place in during the vegetative break or during the growing season in the Northern Hemisphere.

Sequences of annual tree rings allow defining absolute age with annual accuracy. Environmental changes occurring during the tree's growth are recorded in the annual tree rings. Based on the changes in the ratio of stable C and O isotopes in alpha cellulose separated from annual tree rings, reconstruction of paleoclimate changes in the VIII-VII century BC was performed.

[T5] Growth assessment of native tree species from the southwestern Brazilian Amazonia by post-AD 1950 14C analysis: Implications for dendroclimatological studies and atmospheric ^{14}C reconstruction

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The increased number of tree ring chronologies in the Amazon basin has been possible through much scientific effort and important methodological advances in dendrosciences. However, there remains the challenge of finding native species that can be dated to their formative calendar year. In the present study we evaluated tree-ring chronologies from southwestern Brazilian Amazonia by ^{14}C from *Cedrela fissilis* (1875 to 2018), *Hymenaea courbaril* (1840 to 2018), and *Peltogyne paniculata* (1910 to 2018). Seven calendar years for each tree species were selected to undergo α-cellulose extractions and subsequent sample processing for ^{14}C-AMS measurements at the Keck Carbon Cycle Accelerator Mass Spectrometer (KCCAMS) at the University of California, Irvine (UCI). Dendrochronologically dated tree rings and their ^{14}C values were then compared to the Southern Hemisphere (SH) atmospheric post-AD 1950 ^{14}C bomb curves (e.g., SH zone 1-2 and SH zone 3), using the current spatial distribution of bomb-pulse ^{14}C as defined in Hua et al. (2013). Throughout our correlated calendar years and bomb-peak signature results we indicate that *H. courbaril* shows a more erratic sequence of wood ages. At least seven calendar years were not detected during ring counting, or appear to be completely absent. The other two tree species, *C. fissilis* and *P. paniculata*, are annual in nature and can be successfully used in forest growth studies and paleoclimatic reconstructions. Moreover, due to the sampling site's strategic location (9.3° S, 62.9° W) in relation to the Tropical Low-Pressure Belt (Ancapichún et al., 2021), these trees can be used to enhance the limited amount of observational data in the SH ^{14}C calibration curves (Hogg et al., 2013).

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Hogg et al., 2013. Atmospheric Radiocarbon for the Period 1950–2010. Radiocarbon 55, 2059–2072.

[T6] Application of Miyake effect in construction of absolute dendrochronological scale

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Construction of an absolute dendrochronoloagical time scale is a complex proces which is often supported by radiocarbon dating. Unfortunately, simple radiocarbon dating is unable to give accuracy needed to fix relative dendrochronological scale to the calendar period with one-year accuracy. To achieve such goal one may use wiggle-matching method which involves radiocarbon radioactivity determinations of several tree-rings and then matching obtained radiocarbon time-series to radiocarbon calibration curve. We will show similar method, but not based on Intcal/SHcal calibration curves, but on raw ^{14}C radioactivity determinations for specific periods of time for which Miyake Effect has been observed. As the examples raw data from 660 BC, 774 AD and 993 AD will be analysed.

[T7] The potential for using rapid changes in radiocarbon content to accurately date floating pine chronologies from the Hallstatt period

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In Central Europe, the dendrochronological method in absolute dating is widely used, but a significant difficulty in its application is the lack of pine (*Pinus sylvestris*) chronologies covering more than the last thousand years. Recently, long floating pine chronologies covering the last thousand years of the BCE were compiled at the Dendrochronological Laboratory of AGH University of Science and Technology in Krakow. These are mean curves developed from hundreds of trunks of subfossil trees growing in the Puścizna Wielka and Rucianka peatlands. They were preliminarily dated using the wiggle-matching method, while rapid changes in ^{14}C content from 660 BC and excursion starting at 814-813 BC were used for their precise dating with annual precision.

[T8] Bog pine and deciduous trees chronologies related to peat sequences stratigraphy of the Podemszczyzna peatland (Sandomierz Basin, South-Eastern Poland)

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The Podemszczyzna peatland, located in the SE part of the Sandomierz Basin, is a place of peat exploitation for balnaeological purposes (peat is used in the nearby Horyniec health resort). The thickness of organic sediments (minerogenic peat covered with ombrogenic peat) ranges 4.5 m, while the beginning of peat sedentation was dated using the radiocarbon method (^{14}C) at 10 660 - 9 909 cal BP. On the basis of 9 radiocarbon datings, a dept-age curve of peat deposition/accumulation was constructed (according to Bronk-Ramsey, 2017), using the IntCal20 calibration curve (Reimer et al., 2020). During the peat exploitation, numerous fragments of subfossil wood (of various species) were excavated, and based on dendrochronological analyzes and ^{14}C datings (wiggle matching), two short floating chronologies were elaborated: pine chronology (ca 140 years) and deciduous trees chronology (ash, alder, oak) ca 190 years long. Radiocarbon datings has shown that the pine chronology (ca 10 540-10 400 cal BP) was synchronous with the formation of the peat bog: trees could have grown here either before the depositional basin was flooded with water and the formation of the peat bog, or on the mineral islands within the peat bog. In turn, floating chronology of deciduous trees is much younger and is included in time intervals: ca 740-550 cal. BP and is probably related to the terrestrialization of the depositional basin (fen), recorded in the loss on ignition curve in the form of mineral sediment delivery to the bog, as well as in the pollen record.

This study was supported with funds from the Polish National Science Centre (NCN) grant No. 2017/25/B/ST10/02439 (2018–2022).

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[W1] Response of karst sediments to the atmospheric ^{14}C bomb peak

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The global atmospheric ^{14}C bomb peak from 1963 is reflected in ^{14}C activity of natural archives like tree rings, speleothems, corrals, sediments, etc. The attenuation and time delay of the peak in the archives compared to the atmospheric one can be used as a tool to study the carbon cycle of interest.

The sediment cores from lakes Kozjak, Prošće, Gradinsko and Kaluđerovac from the Plitvice Lakes, karst area in Croatia, were retrieved in two sampling campaigns in 2003 and in 2011 on different locations and different lake depths. Some results of ^{14}C activity in the sediment cores dated by ^{210}Pb and ^{137}Cs have already been reported.

Here we present new results for the Lake Kaluđerovac and Lake Kozjak cores collected at the deepest points of the lakes, dated by ^{210}Pb. In addition, ^{14}C activity of laminated tufa that grew from 1979 to 2005 on a wooden pillar immersed in the Korana River is also presented.

The ^{14}C bomb-peak reflection is observed in carbonate and organic fractions of the sediment cores from the middle of lakes, and also in carbonate fraction of the laminated tufa, with attenuation and delay ranging from 28 to 36 years. The intensity of attenuation and delay compared to the atmospheric bomb peak in the laminated tufa and sediments will be discussed in relation with the lakes size and the sampling location.

[W1] Challenges and limitations of the Pb-210 dating method: Results for peats and lake sediments from the High Arctic region

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The ^{210}Pb sediment dating is the most widely used method to determine recent (~100-150 years) chronologies and accumulation rates in varied ecosystems and has been used effectively for the reconstruction of diverse environmental processes associated with global change. Owing to the relative accessibility of the ^{210}Pb methodology, many environmental chronologies have been produced, but not always critically assessed. Sometimes, sedimentary processes such as compaction or local mixing are not taken into account, nor the validity of the fundamental premises and proper estimation of uncertainties assessed. In the face of these problems, the dating exercise was performed using ^{210}Pb, ^{137}Cs and $^{239+240}$Pu activity data for peat and lake sediment cores taken from Spitsbergen, Svalbard Archipelago and the Arctic Archipelago, Canada, respectively. The ^{210}Pb chronologies were based on CF/CS (Constant Flux/Constant Sedimentation) and CF (Constant Flux) mathematical models. In many cases, the incomplete ^{210}Pb total inventory resulting in 'old date errors' by the CF model was noted. Therefore two main solutions were applied. The first was based on extrapolation of missing inventory with the aid of the CF/CS method. The second approach required an accurate reference horizon provided by a time marker. Hence, the key aspects of a sound identification of the ^{210}Pb equilibrium depth, the estimation of the ^{210}Pb inventory and the use of independent markers to corroborate the age models, were established. In general, the study highlighted the relevance of a solid understanding of the fundamentals, assumptions and limitations of the ^{210}Pb dating method and its validation.

[W3] Marine reservoir effect in spermaceti, a wax obtained from the head of the sperm whale

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Spermaceti is a waxy substance found in the head cavities of the sperm whales (*Physeter macrocephalus* or *P. catodon)*. This substance had a variety of commercial applications from the end of the 18th to the beginning of the 20th centuries, such as candles, soap, cosmetics, machine oil, leather waterproofing, rust-proofing materials and many pharmaceutical compounds. Spermaceti wax was also occasionally used as a raw material for modelling sculptures. In order to date such artworks marine reservoir effect has to be determined.

The chemical library of the Muséum national d'Histoire naturelle (National Museum of Natural History, Paris, France) contains historical natural products with more than 1,500 molecules and natural extracts. Among them, samples of spermaceti were studied by the French chemist M. E. Chevreul (1786-1889) during his early work on animal fats. Chevreul reported in his fifth memoir, read at the Académie in 1815 the properties of spermaceti. Eight samples of substances preserved in their original containers labelled *spermaceti*, *blanc de baleine* or *cétine* were ^{14}C dated. According to the whaling practices and the publications of Chevreul, we can estimate that spermaceti samples comes from sperm whales caught at the beginning of the 19th century, probably between 1805-1815. AMS ^{14}C dating results are from 555 to 710 ± 30 BP, with one extreme value at 1125 ± 30 BP. Except for this last result, R values are comprised between 415 to 570 ^{14}C yr and ΔR (IntCal20) between -138 and 18 ± 60 ^{14}C yr with a mean value of -52 ± 60 ^{14}C yr. This result differs from the ΔR mean obtained on 24 whale bones of the Marine20 database (ΔRmean = -154 ± 38 ^{14}C yr) and from 2 values recorded for bones of sperm whales died at the end of the 19th century (Mapno 1074 and 1075, ΔR = -241 ± 28 and -186 ± 23 ^{14}C yr, respectively (Mangerud et al., 2006)). The discrepancy can be explained by the difference of structure between spermaceti, which is liquid and composed of soft tissue (mainly wax), and bones as well as by the spermaceti refining or the variability of the sperm whale locations in the oceans. More measurements are necessary to clarify these points.

[W4] Salgada Lagoon: An Overview of a Brazilian hypersaline lagoon environmental studies over the last 5000 years using radiocarbon dates corrections

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The Salgada Lagoon, in the southeast of Brazil, is one of the few lagoons in the world that has recent well-developed stromatolite representatives. For this reason, it has been the target of many paleoenvironmental geochemical studies, which mostly need geochronological techniques. When analyzing a sample using radiocarbon dating an appropriate data handle is needed. The correct calibration curve must be used and when available the marine reservoir local corrections should be made. In this work, a bibliographic survey was carried out and some results from the consolidated literature were calibrated using the Marine20 curve and a time-varying deltaR in order to modelling the environmental evolution of Paraíba do Sul delta.

[W5] Linking RC and trophic webs in karstic groundwater ecosystems in the Yucatán Península, México.

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Stable isotopes have been used historically to track food webs. Our approach used a combination of $\delta^{13}C$ and Radiocarbon dating to identify carbon sources in cave shrimp within caves of the Karstic Yucatan Peninsula., Mexico. Three sister species of stygobitic *typhlatya* shrimps were collected from the cenote pool (cenote onwards), cavern and cave cavern. Radiocarbon as well as $\delta^{13}C$ contained in the whole tissues from the organisms were determined at the AMS laboratory (LEMA) of the Institute of Physics of the Universidad Nacional Autónoma de México. The isotopic values of potential sources as well as biomass were incorporated into the Bayesian mixing modeling software SIAR (version 4.2). Our results led to the identification of slightly different feeding source among the 3 species of the *Typhlatya* genus.

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[W6] Identification of recycled organic matter in delta sediments using the dual isotopic composition of carbon ($\delta^{13}C$ et $\Delta^{14}C$). New data for the Rhone river delta

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River deltas are crucial areas in continent-ocean interaction. Indeed, they are the major receptacle of the contributions of the rivers and take part largely in the retention and the transformation of the material inherited from the continent. These delta areas are known to be major sedimentation areas and it is estimated that 40% of all the carbon buried in the ocean is in the deltas which constitute only 0.3% of the ocean surface (Cai 2011). One of the ways to approach the issue of degradation of organic carbon in these highly variable media is to study the fate of particulate inputs after their deposition in sediments. The study of the sediment and the water it contains (pore waters) quantifies the mineralization of this organic matter by the accumulation of dissolved inorganic carbon (DIC) released in the pore waters. Measuring the dual isotopic signature δ13C / Δ14C of the accumulated DIC can provide a better understanding of the origin and the reactivity of the mineralized organic matter. Previous papers (Aller and Blair, 2006; Aller et al., 2008; Pozzato et al 2018; Dumoulin et al 2018) have shown that only a fraction of the sediment organic matter is mineralized and can be significantly different from the bulk organic matter in sediments. D14C is used as a tracer of the anthropic carbon contribution and gives precious information concerning the origin of mineralized organic matters. In shelf sediments, mineralization is largely dominated by marine organic matter but in prodelta continental organic matters seems to be preferentially mineralized. In this study we complete our previous works with new data and we check if four years later we obtain similar results. It has thus been possible to show that a selective degradation of the most recent organic materials takes place at the expense of the older and it can create an apparent aging of the sediment. It seems essential to work on the two pools (pore waters and sediment) to better understand these selective mechanisms which have a crucial influence on the source of CO_2 in the carbon cycle of river deltas.

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[W7] Does fresh-water tufa have potential in paleoresearch?

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Tufa is a fresh-water surface calcium carbonate deposit precipitated at or near ambient temperature, which commonly contains the remains of macro- and microphytes. Within the project Reconstruction of the Quaternary environment in Croatia using isotope methods financed by Croatian Science Foundation (2014-2018, HRZZ-IP-11-2013-1623), several locations of fresh water tufa have been found along the Zrmanja and Krupa Rivers, Dalmatian karst, Croatia. Radiocarbon dating of the carbonate fraction of tufa revealed that majority of the samples was formed during the Holocene. However, samples from location Sanaderi found at different altitudes gave a broad range of dates, from modern to older than 50 ky. The samples with ages close to the limit of the radiocarbon method can be dated also by the U/Th method.

Additionally, it was recently suggested that radiocarbon dating of organic residue may lead to more accurate ages that dating of carbonates. Therefore, we performed radiocarbon AMS dating of organic residue of 11 tufa samples from the Sanaderi location, at altitudes between 50 m and 75 m asl. The ages of organic residue of samples, that yielded carbonate conventional ages from 900 BP to 7300 BP, were from modern to 5300 BP. By applying freshwater reservoir correction of 85 pMC to carbonate fraction and 97 pMC to organic fraction (obtained from radiocarbon activity of dissolved inorganic carbon and fresh moss, respectively), both groups of dates agree well.

Radiocarbon dating of tufa organic residue with carbonate fraction ages >20 ky, yielded ages from 7400 BP to 17000 BP. Difference between the organic and carbonate ages increased with the increase of age. The difference cannot be explained by including reservoir correction of 85 pMC and 97 pMC for carbonate and organic fraction, respectively. This is clear evidence that reservoir freshwater effect valid for the Holocene cannot be applied for age correction of older samples. Stable carbon isotope composition ($\delta^{13}C$) of carbonate fraction ranges between -10.5‰ and -8.5‰, with the mean values of (-9.6 ± 0.5)‰ and (-9.7 ± 0.8)‰ for the Holocene and the older samples, respectively. These values indicate the autochthonous origin of the carbonate and negligible contribution of old limestone contamination. The $\delta^{13}C$ values in organic residue ranged from -30.9‰ to-28.8‰, with the average values of (-30.5 ± 0.3)‰ and (-29.6 ± 0.6)‰ for organic residue having ages 5000 BP, respectively. These values suggest a unique carbon source for photosynthesis, mainly atmospheric, i.e., tufa forming plant was the same for all dated samples, with an indication of the Suess effect in $\delta^{13}C$ during last centuries. Since some of the radiocarbon ages of organic residue do not seem credible, e.g., 17000 BP, we suggest a hypothesis of contamination of older organic matter by incorporation of fresh organisms. We extracted humin as the most stable organic fraction and the AMS dating results will help resolving this problem and perhaps give the answers on paleo-freshwater effect. Nevertheless, additional parallel analyses of tufa carbonate fraction and organic residues are needed, if samples of good-quality autochthonous and compact tufa can be provided.

[W8] Comparison of C14 and OSL dating methods for reconstructing the history of a floodplain sediment series over 40.000 years (Jászság, Hungary)

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The aim of the research was geochronological investigation of the Quaternary sediments of the Jászság Basin. In the research area 5 shallow paralel boreholes with an average length of 20 meters were deepened, 2.5 km far from the present Tisza riverbed. There was a sharp change in lithology in the examined rows of layers, which was also investigated by ^{14}C and OSL to determine whether this sharp boundary could be related to a chronological or climatic event. According to the data of the two applied dating methods, almost the whole series was deposited in the Upper Pleistocene, in particular in the Middle Pleniglacial. This is in contradiction with earlier hypotheses that the whole stratum is represented by the Holocene. Nevertheless, only the upper 1.2 m thick Solonec Meadow Soil covers the Holocene formation, directly below which an sediment gap was identified, which is related to a riverbed incision event. The cause of the sharp lithological change was related to a climatic event, the glacial maximum before the last stadial, when the drainage conditions in the area suddenly changed. The 5-8 m thick loamy clay settling beneath the loose soil was 18-23 thousand years old, when it was characterized by a drier climate, so the area became a high floodplain. While the fine-clay rock clay below it is a sediment deposited in low-energy standing water, it is presumably the remains of the "Up-Bodrog". The research was supported by the European Union and the State of Hungary, co-financed by the European Regional Development Fund in the project of GINOP-2.3.2-15-2016-00009 'ICER'.

Keywords: ^{14}C and OSL, Quaternary, Tisza River, flood-plain sediment

[W9] Stratigraphy and AMS radiocarbon ages of the Karekare Swamp, Rarotonga, Cook Islands

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The apparent interruption of deposition (hiatus) between 2.8 and 0.7 cal ka BP (about 130 cm depth) in a 4 m-long core from the Karekare Swamp (elevation 1.65 m; area 0.114 km2) on Rarotonga Island, was found by Fujiki et al. (2014). On Mangaia Island, located about 200 km to the southeast, vegetation changes were also reported to have occurred at about 2.5 to 1.8 ka BP (about 2 cal ka BP), suggesting that humans may have arrived during this period. To determine the hiatus of 2.8 - 0.7 cal ka BP is widely spread in this swamp, which may be related to the arrival of humans and the reason of lacking archaeological sites, we collected the 1150 cm core "Karekare 19-2" using a 5-cm diameter Russian peat sampler (Eijkelkamp Soil and Water, the Netherlands). It consisted of peat from 0 to 17 cm, silt from 17 to 154 cm, peat with very high plant fragments from 154 to 584 cm, silt from 584 to 1076 cm, and sandy silt from 1076 to 1150 cm. We obtained 37 AMS radiocarbon dates for plant fragments from various horizons, and rejected nine dates due to inconsistency with stratigraphy. They were all interpreted as contamination from the upper stratigraphic level at the time of core sampling. The oldest radiocarbon age (1120 cm depth) is 6445 ± 35 BP (NUTA2-28561), suggesting that this core records paleoenvironmental information for the past 7000 years. Between the depths of 100 cm and 90 cm in this core, a time gap of 2.5 cal ka BP and 1.1 cal ka BP is also detected. Therefore, there is a high probability that hiatus is spread in this swamp.

[W10] Effect of marine sediment on DOC solubility and radiocarbon isotopes

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Refractory marine dissolved organic carbon (DOC) is the ocean's largest respired carbon pool and has an average radiocarbon age of 4900 to 6500 ^{14}C years. Yet, the inputs to and outputs from this pool are poorly constrained. Sediments may provide an important role in shaping the composition of DOC by preferentially removing molecules via adsorption, physical entrainment, or precipitation. In this study, we examine how interaction with marine sediments alters the solubility and radiocarbon age of DOC. Suwannee River normal organic matter II was mixed with sediments from the Northeast Pacific Ocean, and then separated by centrifugation and filtration. Solid phase and liquid phase dissolved organic carbon yields and 14C isotopes were measured. In this presentation, we will provide an update on these data. We anticipate that these results will provide insight towards the role of sediments in shaping the chemical and isotopic composition of DOC.

[W11] Storage of groundwaters in flex-foil bags for ^{14}C analysis of dissolved inorganic carbon

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Radiocarbon analysis of the Dissolved Inorganic Carbon (DIC) fraction of natural waters is a powerful tool to establish the time elapsed from the point of isolation of the water from the atmosphere. It is routinely used to establish water entrainment for non-carbonate aquifers and the age of sub-surface ocean waters.

The ^{14}C signature of groundwater DIC can be affected by collection and storage of sample waters. A widely accepted method for collection and storage of sample for radiocarbon analysis of DIC is in amber bottles, capped with indented lids when overflowing to prevent trapping of atmospheric bubbles then wrapping the lid with parafilm. However, these glass bottles are both heavy and fragile and loss of sample water during transport from field to laboratory is a common experience.

This paper describes a study investigating the use of "flex-foil" bags, which are formed from layered sheets of plastic and aluminium, as an alternative to amber bottles for the storage of groundwater samples. We investigated how robust the bags are for use in the field, during transport and during storage, as well as the effect of storage length and method (refrigerated vs. frozen) on the ^{13}C and ^{14}C signatures.

The study investigated three sites comprising two aquifer and one marine, with known ^{14}C signatures which ranged from ^{14}C-free to ambient atmospheric when the samples were collected.

Flex-foil bags were found to be robust in the field and during transport and storage when filled correctly. It was noted that over-filled bags were less reliable during transport and storage as they were liable to split, this was especially true of frozen samples.

Sub-samples of water from the bags were processed for ^{13}C and ^{14}C at intervals between 2014 and 2017. The study shows that freezing is the best method for storage of old "^{14}C-free" samples and that samples of this age can be stored frozen for up to eighteen months before evidence of ^{14}C contamination is seen. Samples with ^{14}C-DIC signatures of > 40 % modern can be stored for up to 24 months and possibly longer. These findings agree with those of Bryant *et al.* 2013 showing that flex-foil bags offer a suitable alternative to glass and plastic bottles for collection, transport and storage of DIC sample from groundwater settings.

References:
Bryant *et al.* 2013. Radiocarbon, 54(3-4)

[W12] Activity approximation as a way for modelling the age of peat sediments

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Nowadays a common trend in the application of the lead method is the use of age-depth modelling with the utilization of Monte Carlo simulations or Bayesian analyses. In these approaches, the approximation of age is utilized. The described work presents a different approach - the application of approximation at an earlier stage - i.e. first calculating the activity, and calculating the age only afterwards. It is an innovative use of the lead method, allowing the construction of the age-depth curve with high resolution.

In the method that uses the approximation, the mathematical function that best describes the course of variability for the measured activities was determined. The determination of this function facilitated the analysis of activity profiles. The presented relation, as well as the method of its determination, may be useful for other researchers utilizing ^{210}Pb lead dating method.

In the situation when the obtained results deviate from the approximated course of activity are observed, it is possible to detect the disturbances in the sediment - and thus we gain better control of the changes occurring in the sediment. The selection of the matching function is crucial not only for the modelling of ^{210}Pb concentrations but also for the age-depth model obtained in the next step. The approximation used at the level of activity makes the lead method independent from Monte Carlo or Bayesian modelling techniques and makes it a more integral, independent technique of dating.

[W13] The development of Nasielna river valley during last 2000 years on the base of sedimentological, geophisical and archaeological data and radiocarbon datings

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The rate and variability of sediments accumulation in river valleys is very often the result of climate change in the past and the intensity of anthropopressure. The research carried out included the analysis of the differentiation of the physicochemical features of sediments occurring at the bottom of the Nasielna river valley (left tributary of the Wkra river) and in the neighboring areas: the slopes and the plateau. The sediments formation and their textural features are the result of complex changes that took place mainly in the sub-Atlantic period, especially during the last 2000 years (dry-wet, cold-warm periods and accelerated human impact on the natural environment). The conducted field studies and the results of laboratory analyzes indicate significant impact of land use changes, especially human economic activity, in the formation of sediments filling the bottom of the studied valley. It was done the geomorphological mapping of the river valley and the neighboring areas as well as the identification of variability in the formation of sediments occurring at the valley bottom. In the samples from geological cores there were measured loss on ignition, carbonetes content and magnetic susceptibility. Age of sediments was determined with the use of radiocarbon dating. The obtained results show that the thickness of the sediments filling the valley bottom was influenced by changes in land use and the local damming of the riverbed from the early Middle Ages and the mill ponds functioning in their hinterland, as well as the variability of climatic conditions in this period. The rate of sedimentation changes were affected both by the land use and climate changes. Higher deposition in the valley bottom was the effect of deforestation and agriculture development especially during 19th c. and begining of 20th c.

[W14] Reconstruction of the Nemunas delta development on the base of sedimentological, geophisical or topographical data and radiocarbon datings

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The presented poster is an attempt to reconstruct the development of the Nemunas delta based on various sources: analysis of archival cartographic materials, geological and geomorphological studies, sedimentological, geochemical and geophysical analyzes, and radiocarbon dating. Field studies were conducted in the summer of 2017 and 2018, on land in the mouth of the river and from boats in the Curonian Lagoon. The results of the conducted research indicate a significant variability of the rate of deposition processes (vertical and lateral) and the speed of delta progradation, both on its land and underwater parts. The reasons for this variability were natural processes (climate change) and various forms of human economic activity (deforestation and use of land for cultivation favoring pro-gradation processes) as well as the construction of a retention reservoir (limiting sediment transport).

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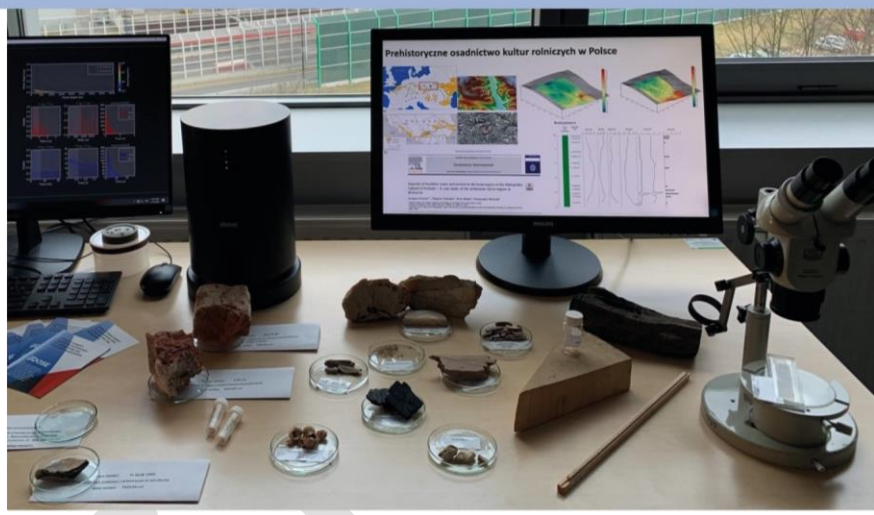

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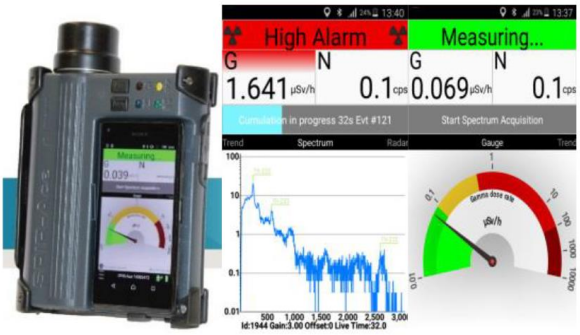

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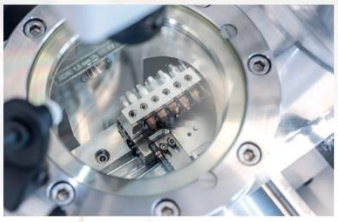

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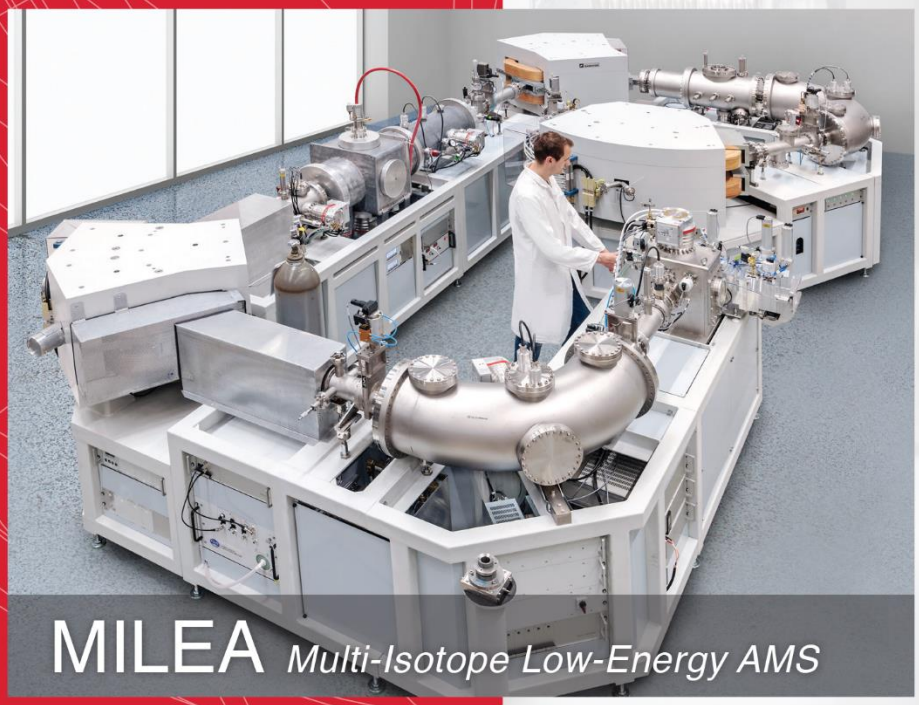

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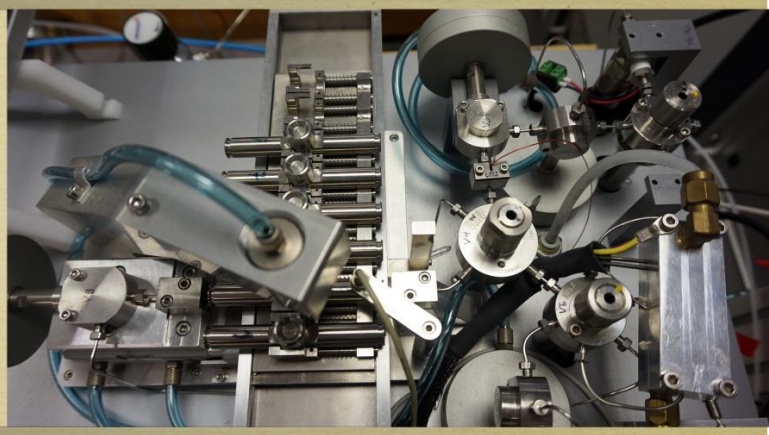

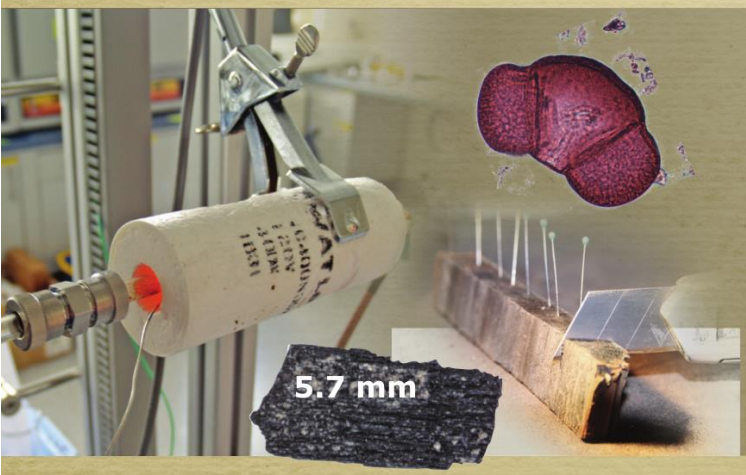

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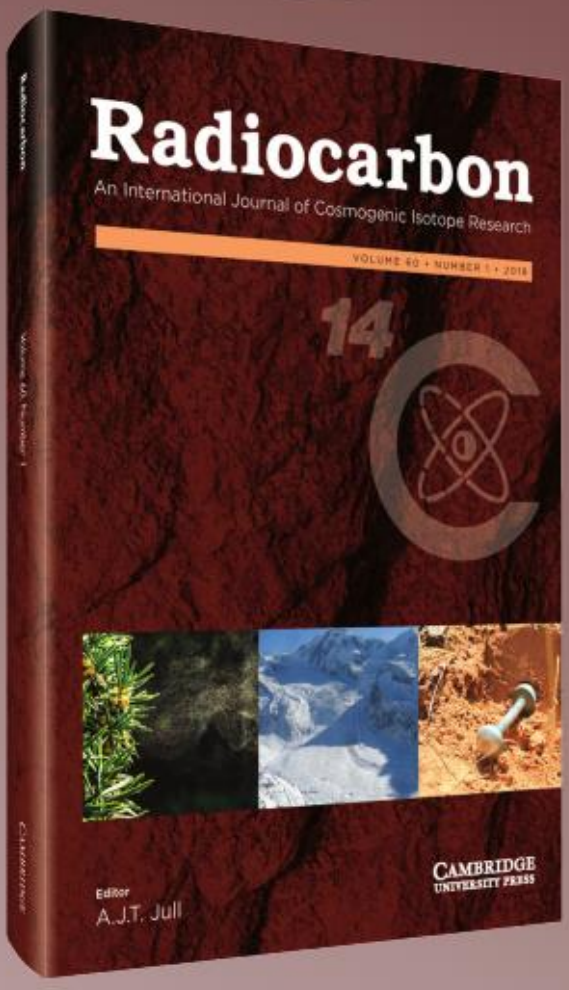

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