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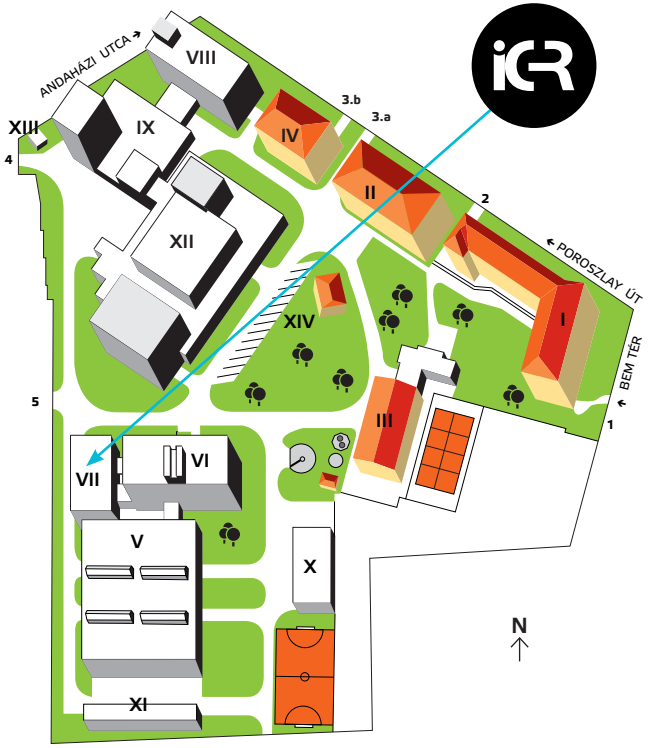

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MTA Atomki DEBRECEN | ICER Isotope Climatology and Environmental Research Centre

ISOTOPE CLIMATOLOGY AND ENVIRONMENTAL RESEARCH CENTRE (ICER)

SZÉCHENYI 2020

HUNGARIAN GOVERNMENT

European Union
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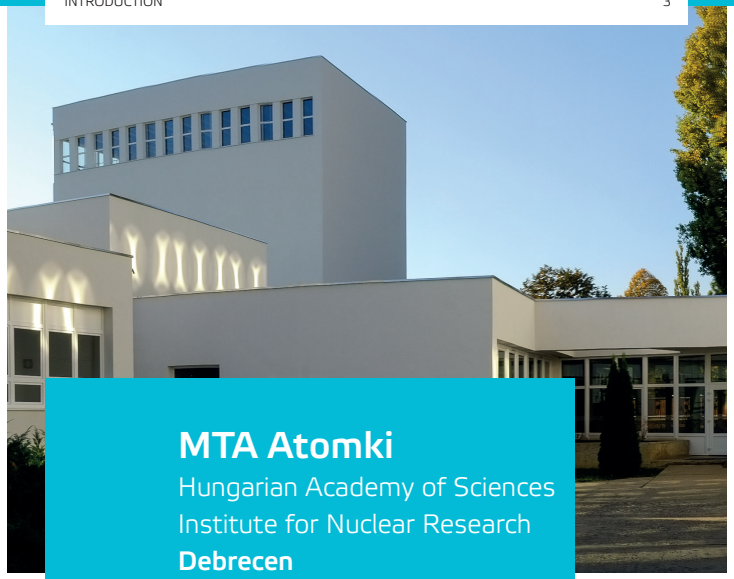

MTA Atomki

Hungarian Academy of Sciences
Institute for Nuclear Research
Debrecen

MTA ATOMKI

Founded in 1954

The Institute for Nuclear Research (short name MTA Atomki or Atomki) situated in Debrecen, is one of the member institutes in the research network of the Hungarian Academy of Sciences. The primary activity of the Atomki is devoted to microphysical research for the understanding of the laws of nature which contributes to the results of scientific research in the world and to the sustainability of the scientific and technological culture in Hungary.

ICER

Isotope Climatology and Environmental Research Centre (ICER)

The environmental analytical studies which are the main research field of the project have been evolving dynamically during the past few years. Our investigations focus on the past and present-day situation of the environment and involve several research fields from the nuclear industry to climate research.

Because of the large number of experimental studies, the development of the research instruments together with their technical, electronic and vacuum technical background plays an important role within the project.The development of state-of-art instruments is an additional individual research field which gives beneficial results and added value to the applied research projects.

Website:
www.iker.atomki.hu

ISOTOPE CLIMATOLOGY AND ENVIRONMENTAL RESEARCH CENTRE

The main focus of the Institute for Nuclear Research in Debrecen is basic research in the field of atomic, nuclear and particle physics and the application of these results

The research direction of the newly-established Isotope Climatology and Environmental Research Centre (ICER) involves those interdisciplinary topics where the field of classical physics can be applied together with other fields (geology, hydrology, meteorology, biology, history and environmental protection) to fulfil the aim of the project.

Relating topics are organized necessarily around a major group of instruments or a certain method. Functioning of the studied fluids coming from all geospheres and anthropogenic sources can be understood sufficiently only by taking account of their effects on each other. Thus, concentrated presence of methods and topics in Institute for Nuclear Research obviously contributes to their individual success.

The significance of the environmental physical research at the institute and the HEKAL group (part of the institute) is shown by the SKI qualification/grade (research infrastructure with strategic importance) received in 2010. This grade was given by the National Research Infrastructure Survey and Itinerary Project (NEKIFUT). The HEKAL group consists of eight different environmental physical research entities within the institute.

RESEARCH

1. – CLIMATOLOGY-PALAEOCLIMATOLOGY

1.1 Carbon in the atmosphere
greenhouse gases and aerosol

Besides CO_2, other components like carbon monoxide, methane and aerosol will be investigated focusing on the ^{13}C and ^{14}C isotope composition. High temporal resolution and long term observation will be done in urban areas as well as a background rural site. The source distribution of these greenhouse gases can be revealed in a state-of-the-art manner.

1.2 Treerings as archives

High precision carbon isotope analyses of tree rings sequences of thousands of years are used to understand long and short term changes in the global carbon cycle. We join an international research targeting to reveal the extreme galactic cosmic ray (GCR) events occurred in the past 2500 years. Trees from the southern hemisphere will be used to study the spatial distribution of the effect of GCR events.

1.3 Reconstruction of palaeoenvirnomental processes by analysis of lacustrine sediment and peat sequences

The aim of this projec is the reconstruction of climatic events and human impact in the past 15 kyr preserved by the sediments, accumulated in high mountain lakes. These lakes are sensitive to the environmental changes. Environmental events occured on the catchment area may result signals in the elemental and isotopic composition of sediments. High mountain lakes were selected for the study from the Carpathians. Peat bogs will be also investigated in frame of this study. One important site will be the Mohos (East-Carpathians, Romania), where the large peat deposit preserved the environmental history of the past 10 kyr.

Installation of a precipitation collector at the Mohos peat bog

1.4 Isotope geochemistry and thermometry from carbonate deposits

One of the research directions in this topic will be clumped isotope thermometry on freshwater carbonate deposits. In addition, biogenic carbonates will be a novel field of application. For instance, clumped isotope analysis of fossil otoliths will help to achieve the first quantitative water temperature reconstruction for the late Miocene Pannonian Lake. Further investigations include the examination of shells of marine and freshwater bivalves, which can be used to examine seasonal events over a period of 100 years.

1.5 Paleoclimate analysis of carbonate formations from caves

The investigation primarily intends to reveal past climate conditions. The laser ablation MC-ICP-MS technique will provide possibility to obtain a higher spatial resolution of age-definition of the studied samples.This technique along with clumped isotope measurements and with fluid-inclusions analysis provides unexplored possibilities in the reconstruction of paleoclimate parameters.

1.6 Analysis of detrital materials from cave ice deposits and polar ice corese

Elemental concentration (Sr, Cr, Cu, Pb, Zn) measurements and isotopic analyses (e.g. Sr, Pb) are going to be done for the first time on cave ice sections located close to historically important industrial centers, which may help in identifying source regions or changes in processing technologies. Using water stable isotopic data, beyond the trace elements, past climate changes and first of all the regional-scale variations of atmospheric circulation can be tracked. Analysis of ice core samples is aimed, on the first place, at constraining source regions of dust accumulated on Greenland during the Last Glacial Maximum.

1.7 Exposure age dating of rock surfaces using in-situ for a better understanding of past landscape evolution

The research will focus on the paleoclimate reconstruction using in-situ produced cosmogenic C-14 for the exposure age determination of glacial landforms and methodological development for the extraction and measurement of in-situ produced cosmogenic C-14 from quartz. Main objectives of the research: (1) Launching an in-situ produced cosmogenic C-14 laboratory in Hungary. (2) A better understanding of the Late Quaternary glaciations in the Southern Carpathians, with major emphasize on the deglaciation process and climate change following the last glacial maximum.

1.8 Research on buried paleosoils

Major goal of this research is the reconstruction of climatic and environmental changes occurred during/around the termination of the last glacial period and early Holocene. Resolution of soil profiles to be investigated is on the order of 10 years, thus can be compared to global records. The clumped isotope method is going to be used on selected secondary carbonates. One of the key questions to be addressed is whether the Dansgaard-Oeschger (D-O) cycles and Heinrich events were recorded in the upper, youngest part of the loess sequences.

1.9 Investigating Late Quaternary megafauna extinction in the Carpathian basin

Megafauna elements gradually disappeared from the Carpathian Basin during the last glacial maximum and in the subsequent Late Glacial period. The aim of this project is to apply AMS ^{14}C dating on Late Weichselian bone collections of large Hungarian museums and this way clarify possible extinction times of the megafauna members. The second aim is to compare extinction times with coincident paleoenvironmental and paleoclimate changes in the Carpathian Basin inferred from the paleoecological study of lake sediments. In addition to radiometric dating, animal bones will be subjected to stable isotope measurements ($d^{18}O$, $d^{13}C$, d15N) that will be used to reconstruct temperature changes between 12-30 kyr BP, and make inference for the diet requirements of the megafauna elements and their yearly migration between regions.

1.10 Climate change in the Mesozoic

During the Mesozoic the mainly greenhouse climate was divided by a number of short and rapid climatic changes, mainly warming events. From six Hungarian outcrops after high resolution sampling of the Triassic, Jurassic and Cretaceous marine sediment successions, using geochemical proxies we can reconstruct the changes in the Tethys Ocean. Our aim is to understand the processes of the geological system from the Late Triassic to the Early Cretaceous, an about 80 million years interval where six main events took place.

Speleothem-based paleoclimate study and installation of precipitation collectors in karst areas in Macedonia

2. – HYDROLOGY-PALAEOHYDROLOGY

2.1 Palaeoclimate reconstruction using groundwater as an archive

The only direct way to reveal palaeotemperatures is the calculation of solubility temperatures from noble gas concentrations dissolved in groundwater. To better understand how temperature has changed during the transition of Pleistocene/Holocene, we intend to broaden our view outside the Carpathian Basin. The following aquifers will be studied in the upcoming research period: Fratesti Aquifer, Romania; Pontian Aquifer, Bulgaria; and Turonian Aquifer, Morocco.

Groundwater sampling in Bulgaria

2.2 Radiocarbon dating of aquiferic waters on Great Plain

Numerous radiocarbon dating studies were carried out on drinking water aquifers of Great Plain in the past 20-30 years. Millions of cubic meter water were pumped out from these aquifer layers since then. The goal of this study to find out how has the age distribution of the investigated water bodies changed as a result of production and how does it influence the maintainable utilization of the most significant water resources.

2.3 Novel and alternative age dating methods of subsurface water (Ar-39, Kr-85)

The half-life of Argon-39 is 269 years which makes it possible to load the application range between the tritium and radiocarbon water age dating methods. In spite of complicated measurement technology, there is a huge demand for it not only in the scientific community but also in the field of sustainable use of water resources. Only one or two laboratories are able to carry out such measurement method routinely in the World (Bern, Chicago, Heidelberg). The purpose of this development to construct gas proportional counter tubes which are able to precise and accurate measurement of Argon-39. The system will be installed in the subsurface National Laboratory of Gran Sasso (www.lngs.infn.it). Beside of Argon-39 measurement the device is also capable to determine the content of Krypton-85 of the investigated samples, which allow of the age dating of young waters (<60 years).

Sampling of river sediments

2.4 Examination of thermal water and thermal springs for their sustainable utilization

The understanding of natural processes connecting to thermal waters are essential for their sustainable utilization. During the research the recent and geologically preserved manifestation and precipitation connected to thermal water are examined in paralell for their comprehensive diagnosis.
The evaluation of recent processes and sampling are carried out in spring caves, wells and in-situ experiments.

2.5 Palaeomorphology of ancient riverbanks

The planned research aims a wide range of investigations in the topics of geomorphology and the water supply of oxbows along the River Tisza and its tributaries. The primary aim is to determine the age of the river beds and the deposited sediments based on the pace and characteristics of lateral erosion of rivers. Besides, we also focus on the spatial distribution and temporal intensity of floodplain using isotope geochemical techniques.

Radiocarbon dating of bones

3. – GEOCHEMISTRY-ENVIRONCHEMISTRY-GEOLOGY

3.1 Atmospheric aerosols

The main objectives of the project are to determine the sources and source contributions of particulate matter pollution in urban, village and remote sites, to characterize the short and long term tendencies, to establish the dependence of source contributions on local meteorological parameters, natural processes and human activities, and to develop adequate analytical techniques for these purposes. Further objectives are to identify and characterize the local, regional and transboundary aerosol sources, to determine the potential source areas of particluate matter pollution.

3.2 Studying the crystalline basement of the Great Hungarian Plain

The purpose of this project aims to study the subsidence and exhumation history of the crystalline basement of the Great Hungarian Plain, which is essential in the research for unconventional hydrocarbon reservoirs. Within the frame of the project, the $^{40}Ar/^{39}Ar$ radiometric age dating method, determination of the Cl/I/Br ratios in fluid inclusions, as well as the fission track methods will be established in our institute. Introduction of the new methods will facilitate us to conduct volcanological, sedimentological and economic geology related research projects in, as well.

3.3 Studying upper mantle rocks

The major goal of this project is to unravel the small- and large-scale heterogeneity and temporal change of Earth's mantle by use of fluid inclusions. Determination of the volatile content (C, O, H, N, He) and isotopic composition of mantle fluids, relying on fluid inclusion petrography, will provide better understanding of the origin and evolution of volatiles in the upper mantle.

3.4 Volcanological studies in the Ciomadul, East Carpathians

Isotope ratios of mineral phases (e.g., $^{87}Sr/^{86}Sr$ in plagioclase and Hf isotope ration in zircons) in the dacitic volcanic product of Ciomadul are used to constrain the origin (mantle and/or curstal sources) of the magmas and reconstruct the magma mixing processes in the crustal magma reservoir. The inner compositional variation of the crystals provides information about the timescale of the reactivation of the crystal mush. Regular analysis of the isotope composition and the flux of the emitted CO_2-rich gases are used to infer about the origin of the gases.

INFRASTRUCTURE

ISOTOPE CLIMATOLOGY AND ENVIRONMENTAL RESEARCH CENTRE

The main aim of the ICER project is to study past and present-day geo-, hydro and biosphere and the complex climate to understand better the past and present-day effects and their application to climate change

The research topics (projects) within the ICER project will be performed using already existing research infrastructure/instruments, which are supplemented with **the newly purchased state-of-art instruments:** the multicollector inductively coupled plasma mass spectrometer and the clumped isotope mass spectrometer. These instruments have not been used previously in scientific or industrial research either in Hungary or in eastern Europe. The state-of-art research infrastructure and our community of experienced researchers provide the opportunity to undertake **several basic and applied research topics** within the frame of the project. Some examples are the clumped isotope thermometry in paleoclimatology research, exposure age dating of rock surfaces using in-situ produced cosmogenic C-14 nuclide to understand better the past glacier movements and the high-resolution measurements of the fossilized carbon-load of the atmosphere.

Multicollector inductively coupled plasma ion source mass spectrometer (MC-ICPMS)

A Neptune Plus MC-ICPMS has been installed

For the first time in Hungary, which will strongly contribute to the determination of non-conventional isotope ratios with epsilon precision so that state-of-the-art research is performedPrimarily $^{234}U/^{230}Th$ age determination of carbonates will be adapted as well as $^{87}Sr/^{86}Sr$ isotope ratios of rock, groundwater and archaeologic samples (e.g. bone, finding). For geochemical research iron ($^{56}Fe/^{54}Fe$), copper ($^{65}Cu/^{63}Cu$) as well as $^{30,29}Si/^{28}Si$ isotope ratios will be also applied using the MC-ICPMS and the clean laboratory of Class 1000.

LosGatos spectrometer

Two laser based Liquid Water Isotope Analyzer were installed, which are suitable for measuring δ^2H, $\delta^{18}O$ and $\delta^{17}O$ of water samples

The instruments operate on the principle of laser-based absorption spectroscopy, which is an accurate optical absorption method for measuring isotopologues ($H_2{}^{16}O$, $H_2{}^{17}O$, $H_2{}^{18}O$, H_2HO) in a single gas matrix.

MAT253 Plus mass spectrometer

A Thermo Fisher Scientific MAT253 Plus type isotope ratio mass spectrometer and a Thermo Fisher Scientific KIEL IV automatized carbonate device is under installation in the ICER

This system is suitable for measurement of traditional carbon and oxygen isotope ratio of low weight carbonate samples down to 20 µg. Besides that the carbonate clumped isotope thermometry will be the main use and research field of this dedicated system in our laboratory. The clumped isotope method is going to be used on various type of carbonates (fresh water carbonate deposits, biogenic carbonates, fossil otoliths) for the purpose of past climate parameter reconstruction.

Two Picarro Cavity Ring-Down Spectroscopy analysers

Two Picarro Cavity Ring-Down Spectroscopy (CRDS) analysers installed at ICER Centre for Real-Time Atmospheric Monitoring of Stable Isotopes and Trace Greenhouse Gases as CO_2 and CH_4

The **Picarro G2201-i Analyzer** combines capabilities of two carbon isotope instruments for CO_2 and CH_4into a single instrument. Using this instrumnet Researchers can follow carbon as it moves from source to sink with a single instrument. Its small size and robustness make it easy to transport to the field, where immediate results allow researchers to change course on-the-fly and achieve optimal results from limited-time field campaigns.

Existing (already installed) infrastructural instruments

- **EnvironMICADAS AMS** accelerator mass spectrometer and preparation laboratory for the C-14/radiocarbon measurements
- Gas proportional counting technique (GPC)
- Noble gas mass spectrometer **Fisons VG-5400**
- **Thermo Finnigan Deltaplus XP** stable isotope ratio mass spectrometer
- Laboratory for low-background gamma and beta-spectroscopy
- Laser Ablation Inductively Coupled Plasma Mass Spectrometer

Instruments and equipment under acquisition

- C100/ISO5 clean laboratory
- Large-volume aerosol sampling tool/equipment for C-14 and isotope analytical measurements
- Instrument for preparation of dissolved organic carbon in water for C-14 measurements
- Rock preparation instrument for in-situ C-14 measurements
- Instrument/equipment for tree ring preparation
- Proportional counter tube for ^{39}Ar measurements
- Preparation line for bottled-air to measure C-14 from trace gases
- Polarizing microscope and its supplementary units