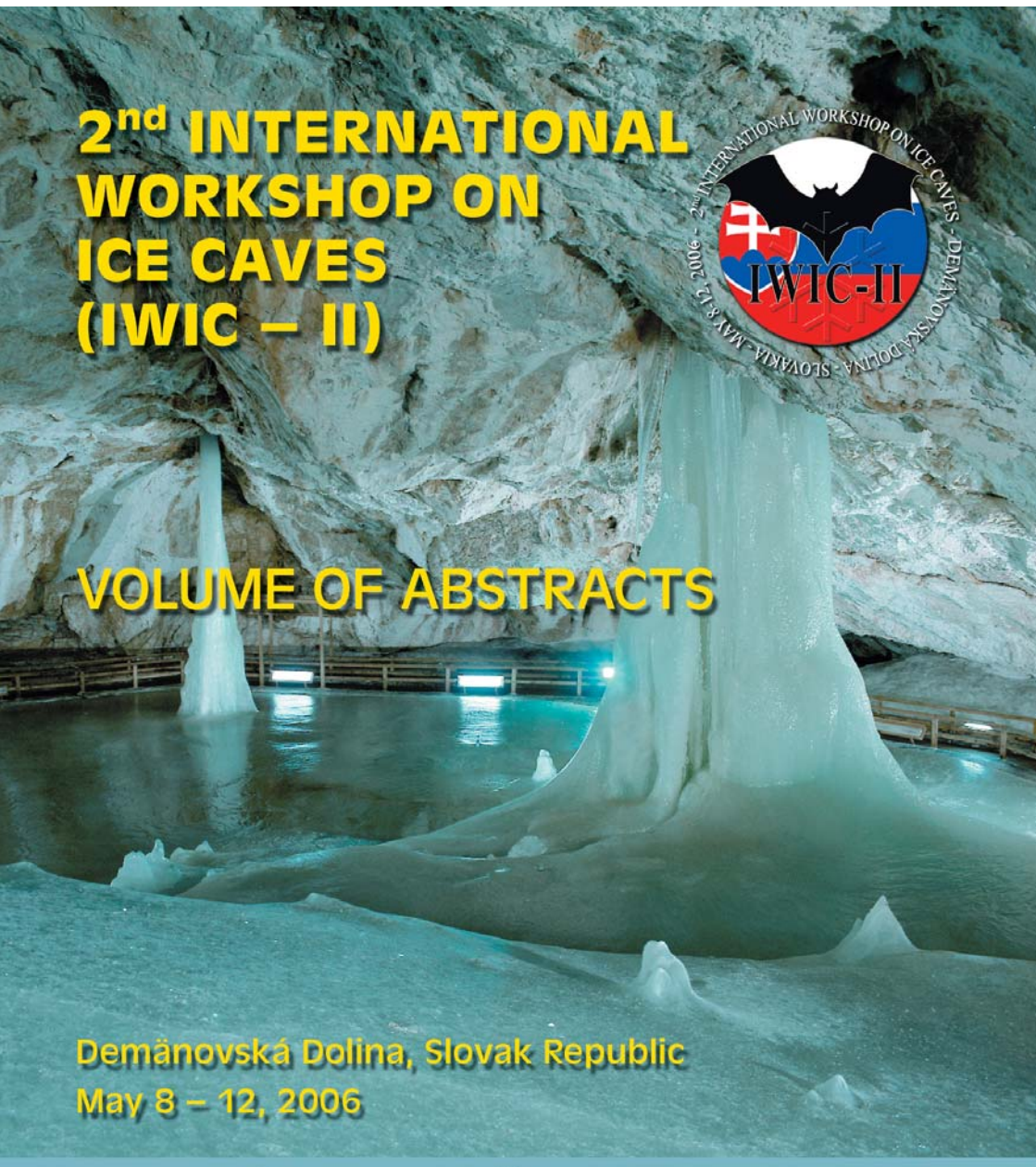
May 2006

2nd International Workshop on Ice Caves International Workshop on Ice Caves

International Workshop on Ice Caves

2nd INTERNATIONAL WORKSHOP ON ICE CAVES (IWIC – II)



VOLUME OF ABSTRACTS

Demänovská Dolina, Slovak Republic
May 8 – 12, 2006

Organized by:

SLOVAK CAVES ADMINISTRATION

UNIVERSITA' DEGLI STUDI DI MILANO
Dipartimento di Scienze della Terra "Ardito Desio"

WROCŁAW UNIVERSITY
Institute of Geography & Regional Development

UNIVERSITA' DEGLI STUDI DI MILANO – BICOCCA
Dipartimento di Scienze dell' Ambiente e del Territorio

Under the auspices of:

UIS – GLACKIPR
Glacial Caves and Cryokarst in Polar and High Mountain Regions Commission

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Edited by
Stefano Turri & Jan Zelinka

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Slovak Caves Administration, Liptovský Mikuláš, Slovakia

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FOREWORD

Dear Colleagues

we are pleased to host you at the second International Workshop on Ice Caves (IWIC-II) in Slovakia. The first IWIC-I was organized in Romania two years ago. Participants from many countries were fascinated by admirable natural phenomena of Scarisoara Ice Cave. This series of international workshops is oriented to complex geoscientific research and protection of caves with permanent ice and snow deposits.

A lot of new knowledge on these caves with remarkable climatic, glaciological and other subterranean environmental features from many countries will be presented during IWIC-II. More than 25 oral and posters presentations have been registered by now. We are preparing also two round tables for more detailed discussions related to selected problems of ice-filled cave climatology, glaciology and other topical issues. We attempt to print the proceedings of IWIC-II by the end of 2006.

The programme of IWIC-II contains also three field full day excursions. You will visit the famous Dobšiná Ice Cave (World Heritage) with the Duča ice-filled collapsed doline in the Slovak Paradise National Park, well-known caves in the Demänová Valley including the spectacular Demänová Cave of Liberty and Demänová Ice Cave, and several important caves in the Slovak Karst National Park (Gombasek Cave with straw stalactites, Silická ľadnica Ice Cave located only 503 m a.s.l.). Also the visit of Ochtiná Aragonite Cave (World Heritage) is included into the programme of post-workshop excursion. We will visit significant Central European areas of middle mountain karst of monocline structures in the Nízke Tatry Mts. and plateau karst in the Slovak Karst.

We hope the IWIC-II will be successful and important event for future activities of scientific community interested in wide-ranging topics of ice-filled caves.

We wish you a pleasant stay in Slovakia.
Sincerely yours,

RNDr. Pavel Bella
Prof. Alfredo Bini
Prof. Valter Maggi

ORAL PRESENTATIONS

MORPHOLOGY OF ICE SURFACE IN THE DOBŠINÁ ICE CAVE

Bella P.

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The ice-filled part of Dobšiná Ice Cave (Slovak Paradise National Park, Slovakia) is located at 920 – 950 m a. s. l. The volume of ice block in the cave is ca 110,100 m^3. The extent of ice surface is ca 9,770 m^2. Several long-lasting and ephemeral forms of the ice surface were developed.

Long-lasting forms are presented by (1) supraglacial ice-deposited forms (horizontal or subhorizontal ice floors, evenly inclined or cascaded ice slopes or tongues, small ice tongues on steep rock walls, icefalls, ice stalagmites and mounds, ice stalactites, ice columns), (2) supraglacial ablation forms (sublimation large scallops and flutes on ice walls, sublimation steep ice walls, ablation window-holes, ablation ice irregular protrusions, ablation oval mound-shaped elevations, ablation bevels at the edge of flat ice floors, melting depressions near electric spotlights, artificial notches of tourist path in ice floors and walls), (3) supraglacial compounded ice-deposited/ablation forms (flat ice floors), (4) intraglacial ablation forms (sublimation large scallops and flutes on ice walls of artificial tunnels in the ice block, sublimation ceiling cupolas in the artificial tunnels, melting ceiling cupolas above the electric spotlights in the artificial small hall, artificial ice tunnels in the ice block).

Seasonally ephemeral supraglacial ablation forms are observed (egutation shallow plate pits, egutation deeper bowl-like pits, egutation well-like pits ablation, egutation more-pits depressions, ablation pinnacle karren, ablation shallow pans, egutation kettle-holes, egutation well-like depressions, ablation vertical half-tube grooves on ice columns, ablation rinnenkarren, ablation small shallow meandering channels on a flat ice floor, ablation outflow channels from egutation well-like depressions and larger kettle-holes, loaf-shaped ice bulges with radial cracks caused by expanded volume of freezing water in deeper places of supraglacial lake, artificial outflow channels in the ice floor along the tourist path).

Ablation forms originated in consequence of dripping and flowing water, air circulation and convection, and development of the cave for tourism. Flat ice floors are developed in places where the changes of the phases of intense dripping waters, lake accumulation and stagnation of waters with melting and feezing of ice are repeated. They are located on top position and on lower barrier slope or foot position of ice block at the contact of ice and non-ice cave parts. Ablation bevels inclined to the centre of occasional shallow ice lake were extended downward after gradational ablation lowering of flat ice floor.

THE NATURE AND MYSTERY OF UNNATURAL ICES

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7 kinds of unnatural and mysterious ices near ground worldwide will be introduced. And the nature and characteristics of them will be discussed. Especially on the ice valley -1 in Miryang Korea, author gave big efforts to solve the mystery and some thing he found will be summarized.

1. Ice valley

a. Ice valley 1.

In Korea there is a place called ice valley where ice is forming at spring and persist to summer. But no ices are found in cold winter. Some research studies on this mysterious phenomenon are accumulated after 1968. This year a warm wind hole where the hot air coming out through whole winter season was founded and the documents were published by me. Though, many things are still in mystery. Many photos, video images and observation results are available. Similar wind hole is found in Nakayama Japan.

b. Ice valley 2.

At one Oasis in desert of Mongol, there is a place called ice valley. In this region ice persists until late August when air temperature is over 30 °C. No meteorological observations or studies have been published on this yet. Photos are available.

2. Ice cave

In ice cave is different from ice valley. It means the ice remained to summer in the cave. Some places in the world for tourists will be introduced. One is at USA the others are in Austria. And many places are in Slovakia. Not the mechanism but the natural scenery with big ice is interesting.

3. Ice spike

There is a place in Korea where the ice bars grows upward frequently and naturally from the surface of water bowl in outdoor. It has been observed for 20 years and introduced. Mechanism and characteristics will be introduced too. Photos and video images of growing ice are available.

4. Ice tunnel

In the train tunnel underground, about 1,000 beautiful icicles growing upward are found every year. It is located in Yeon-Chun Korea. Explains and photos are available.

5. Ice lake

Some lakes (in Russia) have ice in hot summer when air temperature is over 30 °C. If a man stands over the ice in lake, he feels hot in face and cold in feet. In this area minimum air temperature reaches to -60 °C in winter. But cold water coming out continuously from underground during winter and the thickness of ice goes to 4 m high. Photos and video images are taken. Mechanisms are discussed.

6. Ice barricade
X-shaped ice barricade with 1 m high and a few km long arises over the lake surface on very cold winter dawn. They called it the Dragon's Agriculture. Mechanisms are partly known. It is observed from long time ago but still mysterious. No photographs are available now.

AIR TEMPERATURE IN AN ICE CAVE: THE EXAMPLE OF FOCUL VIU ICE CAVE (BIHOR MTS., ROMANIA)

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[3] "Politehnica" Caving Club

Focul Viu Ice Cave is a small, descendent cave in the central part of the Bihor Mts., Romania. It is located at an altitude of about 1165 m, in the upper part of a limestone ridge. A small entrance is giving access to a large chamber ("Big Hall", 68 x 46 m), followed by a smaller one ("Small Hall", 20 x 5 m). The floor of the Big Hall is fully occupied by a massif ice block (25,000 m^3), while the second room is missing this feature. The ceiling of the Big Hall is open to the sky through a large shaft, located at a higher level than the entrance of the cave.
In March 2004 a number of 3 temperature data loggers were installed in the cave: in the Big Hall, in the Small Hall and in the shaft, while a fourth one was measuring the temperature in the outside of the cave, near to the entrance.
In this paper we present the results after one year of air temperature monitoring. Analyzing the obtained data, we can distinguish two intervals during one year: summer season, between April and October and winter season, from November to March.
The collected data show a strong correlation between the external and the internal air temperature as long as the outside temperatures are below 0 °C, when cold external air is entering the cave through the lower entrance and is pushing out the warmer air through the shaft in the Big Hall. The internal air temperature is close to 0 °C all year long, with a slight increase (less than 1 °C) during the summer, as a consequence, during summer, no air exchanges are active between the exterior and the cave. The stochastic analysis is showing that there is no cause-effect relation either between the air temperature of the two chambers or between the external and cave air temperature, while a strong influence of the ice block over the cave's temperature can be recognized.

STABLE ISOTOPE STUDY OF DIFFERENT WATER SOURCES IN THE BORȚIG ICE CAVE, APUSENI MTS, ROMANIA

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Borțig Ice Cave (46.56 N, 22.69 E, 1236 m a.s.l.) is the second largest ice cave of the Apuseni Mountains, containing 30,000 m^3 of ice. In order to reveal the origin of the water involved in the formation of the subterranean ice body we have launched a regular observation campaign in the cave. Simply collector equipments were installed in the cave following the suggestions of GNIP. Liquid water is being collected by cautiously prepared plastic funnels and barrels in two significantly different positions of the cave. The upper microstation is situated bellow the entrance shaft so that the collected water is dominantly the atmospheric precipitation, while the lower station is situated at inner part of the cave, so we regard this water as mixture of seepage water and dripping water running-off the rock wall. Drifted snow is also being collected by plastic boxes. All containers were discharged once a month and the stable isotope compositions were determined.
Results and observations after three months are displayed here.

	δ18O [‰] VSMOW		δD [‰] VSMOW		d-excess	
	upper	lower	upper	lower	upper	lower
17. 09 – 14. 10 2005	-9.24	-9.95	-61.1	-62.1	12.8	17.8
15. 10 – 17(18). 11 2005	no precipitation		no precipitation		no precipitation	
17(18). 11 – 10. 12 2005	(rain) -11.10 (snow) -13.02	-9.69	(rain) -69.85 (snow) -85.25	-59.6	19.0 18.9	17.9

The stable isotopic composition of the precipitation and seepage water samples collected in the ice cave are over the Global Meteoric Water Line (GMWL). This observation and the calculated d-excess values (see table) indicates the "elevation effect" on the isotopic composition as the Borțig Ice Cave is situated at 1236 m a.s.l. This elevation effect must be characteristic for the other ice caves in this region (Apuseni Mountains).
Stable isotope data of block ice in the Borțig Ice Cave will be presented as well.

CREATION OF THE SYSTEM OF MONITORING OF KUNGUR ICE CAVE

Kadebskaya O. I.

Kungur lab of Mining Institute of Ural branch of RAS

Kungur Ice cave has been described more, than 300 years ago. Since that time, more, than 500 scientific papers and near 100 popular ones had been written about it. Almost 100 years the cave is actively visiting by tourists, last 50 years – cave is a constant subject of exploration works, carried by scientific lab, placed next to it. In the Kungur Ice cave also is a basis for Perm State University student's practice. In 2001, according to the Federal law «About especially protected territories» and to the Law of the Perm region «About historic-cultural and nature heritage» nature sanctuaries «Ice mountain» and «Kungur Ice cave» has became part of the historic-natural complex «Ice mountain and Kungur Ice cave».
Among largest caves on territory of Russia, Kungur Ice cave, with its length 5.7 km, has unique characteristics, which are placing the cave in a list of especially valuable objects of nature. Also, the cave is very sensitive to any anthropogenic influence. Thus, at present, without organization of complex monitoring inside the cave, further exploitation it as touristic object is impossible. Specialists of Kungur lab of Mining institute of Ural branch of RAS is carrying observations of the cave from 1948 y. In 2005 there was created the new project of monitoring of the cave. It include these parts:

- Geological monitoring
- Hydrological monitoring
- Hydrogeological monitoring
- Hydrochemical monitoring
- Microclimate monitoring
- Glaciological monitoring
- Management and restoration of ice sediments in the cave

In the cave, in first time in Russia, will be installed electronic system for performance of whole complex of monitoring, manufactured by Integrated Seismic System (South Africa).

RADIOCHEMICAL AND STRATIGRAPHIC ANALYSIS OF TWO METRES LONG ICE CORE FROM BORȚIG ICE CAVE, APUSENI MTS, ROMANIA

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Borțig Ice Cave (46.56 N 22.69 E 1236 m a.s.l.) is the third largest ice cave of the Apuseni Mountains, containing 25,000 m^3 of ice. Two ice cores were drilled in the ice block situated at the bottom of the entrance shaft of the cave on 11th and 12th of December 2005.
The first core (BA) reached 209 cm depth below the actual ice surface and sliced into twenty pieces. During the parting we made special efforts to develop segments representing equidistantly 10 centimetres of real ice depth, as during drilling the core was distorted.
The second core (BB) reached 197 cm depth below the ice surface. This length was separated into ninety-four sub-samples. Each sample represents about 2 cm interval of the real depth.
As we are looking to find absolute marker horizons (depth of appearing of 3H, peak before nuclear silence) in the ice block the tritium concentration along the cores were determined. On the basis of a theoretical growth curve of the ice cave we estimated that the upper two metres of the ice mass must cover the period at least from 1940, anyway natural tritium content before this date surely decreased below the detection threshold due to the half-life of 3H.
The tritium activity was measured on water using liquid scintillation technique and Tri-Carb 3170 TR/SL device.
Pilot measurements on samples of BA core suggest that the highest tritium concentrations are from BA8 to BA11 between 71 and 112 cm below actual ice surface.
Beside the radiochemical investigations we have also developed classical stratigraphic observations. We noticed ice layers with different physical properties within both ice cores. In general view the cores were cyclic sequence of higher and lower density ice layers. The core profile suggested that a less dense and a denser layer coupling together and form one higher order stratigraphic unit. At the middle and bottom section of the cores the ice was more compact, here it was more difficult distinguishing the layers.
Impurity layers scarcely appeared in the cores. BA had a better and a less developed ones, while BB had only one. The BB dust layer and the bigger BA layer settled in the same calculated depth, suggesting the correspondence. However, sixteen couples of unit were distinguishable above the dust layer in BA core and fifteen in the BB core by layer counting

following the core extraction. The discrepancy probably originates from miscounting because the material deformed during the process of core extraction that complicates the determination of narrow layers.

INVESTIGATION OF NATURAL PERENNIAL ICE DEPOSITS OF DURMITOR MTS, MONTENEGRO

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Durmitor Mts is prominent range of Dinarides having a very spectacular geomorphologic view owing to the concomitant evolution of karstic and glacial landscape. A special phenomenon of the glacial feature of Durmitor Mts is the synchronic appearance of surface and subterranean glaciations. Debeli Namet (43.12 N, 19.28 E), the southernmost glacier remnant of the Balkan Peninsula and Ledena Pecina (43.14 N, 19.04 E) the ice cave of Durmitor Mts.
In order to estimating the age and deposition dynamic of the different type of icy deposits we extracted shallow ice cores from both ice bodies.
The drillings were executed at Debeli Namet on June 17, 2002 and at the ice cave at June 18, 2002. We assessed the upper 220 cm of the Debeli Namet as recent snow deposit from the last accumulation season so we started the drilling process at base of snow layer and the core covered the 2.2 – 3.93 m depth interval, however the ice core from the ice cave penetrated the uppermost 0 – 1.99 m depth interval.
^{137}Cs isotope concentration of melted samples was measured by gamma spectrometry method.
The preliminary results of the ice cave suggest coherent decreasing concentration of ^{137}Cs isotope towards the deeper part of the cave ice. The results from the glacier show much higher deviations and do not imply any consequent tendency.
Stable oxygen isotope compositions are determined for a few samples. But the control measurement after a few months yielded significantly higher 180/160 ratio for the same samples. This finding spoilt sense of any further analysis of stable isotopes of H_2O molecules. We can attribute the modification of stable isotope composition to the inappropriate sample transportation and sample storage.

CARBONATE POWDERS IN FREEZING CAVES

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Cryogenic cave calcite occurs naturally in freezing caves where bicarbonate-rich water discharges into sub-freezing openings. The presentation will focus on the description of the calcite powder. We will present SEM photos and results of isotopic analyses from samples collected in northern Yukon and in the Ottawa region. An hypothesis will be presented for the formation of the powder. Following this hypothesis the powder is created by ice sublimation: the reaction between the carbonate calcium and the CO_2 released during the sublimation is at the origin of the calcite powder. In conclusion, we will compare cryogenic calcite powder with cryogenic aufeis (or icing) calcite associated with arctic springs and to calcite rafts from pool waters in temperate and warm caves.

DIATOM FLORA IN FREEZING CAVERNS AND SLOPE CAVES OF NORTHERN YUKON, CANADA, IN RELATION TO THE SUBTERRANEAN ENVIRONMENT

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In the late 1980's and early 1990's, 125 samples were collected from various karst environments in Northern Yukon for diatom analysis. Efforts were oriented towards collecting calcite-rich sediments and ice samples from freezing caverns and slope caves. The objective was to make an inventory of diatoms, and to explain their distribution in relation to the various cave environments. The results show that approximately 20 % of diatoms originate from external biotopes and habitats (e.g., rivers, lakes, streams). The remaining 80 % is of local origin (e.g., from sub aerial habitats nearby cave entrances). These results are a contribution to the dynamic of water condensation and to the transport of aerosols in freezing caverns.

PARALLELS BETWEEN GLACIOSPELEOLOGY AND SPELEOGLACIOLOGY

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Objects of researches of glaciospeleology are caves in glaciers. Objects of researches of speleoglaciology are accumulations of snow and ice in underground cavities and the reasons of their formation in them. In the position in space objects of researches of these scientific directions are seldom crossed as rather seldom find caves in glacial areas. An example of crossing is Castleguard Cave in Canada where glacial ice flow directly in a karstic cavity. As indirect crossing we can use formation of glaciers in karstic caves that meets rather seldom.

It is possible to allocate the following similar positions of these objects:

1) Similarity of structure and morphology of the snow-ice formations accumulated in cavities;
2) Common principles of cavities formation in ice and in soluble rocks;
3) Partly agreements of morphological features of cavities favorable for cold accumulation in karstic cavities and in ice;
4) Similar sources of water for formation of secondary ice in cavities.

It is possible to allocate such basic distinctions:

1) Distinction in containing rocks (ice and other rocks); features of cavities existence in many respects are determined by properties of containing rocks;
2) Different sources of cold in cavities (in karstic cavities - winter cooling by air, in ice – cooling by containing rock);
3) Situation of objects mainly in different geographical zones.

It is possible to allocate such points of mutual penetration of objects:

1) Flowing of glaciers in karstic cavities and formation of cavities in cave glacier ice;
2) Formation of natural cavities in cave ice of karstic cavities;
3) Formation of natural cavities in cave ice of glacial cavities;
4) Formation of secondary ice formations in cavities in cave ice.

Being completely different natural objects, objects of researches of glaciosleleology and speleoglaciology mutually influence against each other. This influence in many respects depends on degree of level of objects studying. Therefore studying of each object separately may give additional information for knowledge of other object.

THE PAST, PRESENT AND FUTURE OF THE LIGHTING EQUIPMENT IN DOBŠINÁ ICE CAVE

Novomeský J.

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Presentation of special technical information based on our own design and installation of cave lighting equipment (CLE) in the Dobšiná Ice Cave and the comparison with some CLE's of others icecaves. They shoul'd help us to plan the new CLE's more friendly and inoffensive to the caves environment in the future.
Recommended and "forbidden" lamps, suitable luminaries, design, installation, control and operation of CLE's. Something about the use of colours and the light effects.

RECENT INVESTIGATIONS IN AUSTRIAN ICE CAVES

Pavuza R., Mais K.

Dept. of Karst and Caves, Museum of Natural History Vienna

A brief overview about the distribution of ice caves in the Austrian Alps is given.
Some examples deal with the development of the ice bodies in major ice caves in the "Dachstein Cave Park" where a constant decline even in the undeveloped parts of the show caves can be observed. Long term temperature series help to develop models for the dynamics of the cave ice.
A few ^{14}C-determinations on organic inclusions yielded late medieval ages, implicating that these caves were free of ice at least once in the holocene. In one of the caves a maximum ice age of some 4000 years b.p. could be observed.

3D-GEOMETRY OF LODOWA IN CIEMNIAK ICE CAVE – IMPLICATIONS FOR WATER AND AIR CIRCULATIONS

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Lodowa in Ciemniak cave is the largest ice cave in the Polish part of the Tatra mountains. Its climate belongs to the dynamic type. Ice mass, which is hosted in the cave, is in continuous degradation during the last century. As the present authors previously documented, the ice body is increasing during springs and is decreasing throughout the rest of a year. The decrease is due to melting in summer and autumn and due to sublimation in winter. The later was found to contribute about 30 % of the total annual ice mass loss. To better explain the factors responsible for ice mass balance fluctuations and possibly to tie it with regional climate change pattern a study on 3D geometry of the cave was conducted. The objective was to determine all the possible routes of air and water migration as well as thickness of rock mass separating cave from the earth surface. To obtain the 3D picture a classical cave mapping along with a high resolution differential GPS mapping for earth surface and geodetic survey in the cave were applied.

The cave system is showing in general E-W development which is parallel to surface slope inclination which reaches in average 40 degrees. The two vertically oriented parts of the cave, located in central and end part, are elevated up to 40 meters above the surface of the ice body covering its floors, descending down to –11 m below the cave entrance. In relation to the surface the central chimney system is separated with about 8 to 10 meters of rocks in its explored part. Its development in the zone of intralayer and tectonic fissures causes that it is the main artery of water supply to nourish perennial ice cover in the cave. At this stage of observations there is limited evidence of seasonal changes in cave ventilation through other ways than the only entrance. Works on more detailed 3D mapping and exploration of the cave are still in progress.

ICE AND SPELEOTHEMS – NEW INSIGHTS FROM U/Th DATING AND STABLE ISOTOPES

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Ice and speleothems are mutually exclusive. Apart from volumetrically insignificant cryogenic precipitates present in some ice caves, common speleothems such as stalagmites, flowstones and stalactites only form when the cave's temperature is above the freezing point of water. As a result, speleothem growth as identified by U/Th dating can be used as a reliable paleoenvironmental indicator, in particular in cold climate regions.

In addition to ice accumulating inside caves glaciers forming on top of caves are also known to stop speleothems from growing, either by cooling the cave below the freezing point or by flooding of the cave by melt water, not to mention the lack of soil-derived carbon dioxide input into the karst system in such subglacial settings. While this is certainly true for the vast majority of dripstone caves, there are rare examples where speleothem growth continued even beneath a glacier or an ice sheet, e.g. Castleguard Cave, Alberta. The interior of this cave lies beneath the Columbia Icefield and moderate carbonate (and gypsum) precipitation appears to be ongoing based on water chemical analyses. Key to this process is a combination of elevated geothermal heat flow and the presence of sulfides in the host rock, giving rise to acidic seepage waters as the primary agent of karst dissolution.

Some caves in the Eastern Alps of Austria are presently situated above the timberline and adjacent to retreating glaciers. Despite their altitude and temperatures only slightly above freezing these caves contain calcite speleothems, both active and inactive. Speleothems there form(ed) by a combination of karst dissolution fueled by pedogenic carbon dioxide and by inorganic oxidation of disseminated sulfides within the (partly crystalline) rock. Within the frame of a multiannual research project a series of flowstone and stalagmite samples were dated by U/Th (in Heidelberg) and analyzed petrographically and geochemically (at Innsbruck) resulting in a data set of approximately 300 high-precision U/Th dates and some 21,000 stable carbon and oxygen isotope data. These data provide strong evidence that in these caves speleothem deposition occurred not only during interglacials (such as today), but also after the glacier had expanded above the cave as a result of a drop of the equilibrium line altitude. This is shown by U/Th dating results in conjunction with stable isotope data and it will be argued that the presence of a warm-based glacier on top of the cave may actually have enabled Pleistocene speleothem formation in the first place.

DEVELOPMENT AND DEGRADATION OF ICE CRYSTAL SEDIMENT IN DOBŠINÁ ICE CAVE (SLOVAKIA)

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The study presents the pattern of development and degradation of sublimation ice (ice crystal sediment) in Dobšiná Ice Cave, taking into consideration the directions of energy flow between the orogenic belt, the cave air and the ice filling of the cave. The determination of changes of the range of occurrence of these forms during subsequent years, including the evolution of the size and type of crystals constituted the basis for the pattern (model) elaboration. The results of the sediment range charting were compared with the results of investigations carried out in parallel on the movement and exchange of air in the cave system as well as with the results of the rock temperature measurements conducted in the years 1980-1984.

SELECTED FEATURES OF MICROCLIMATE IN THE DEMÄNOVÁ ICE CAVE (SLOVAKIA)

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In the research paper, the authors presented a summary of microclimatic investigations carried out so far in Demänová Ice Cave. The study makes use of the results of current registration and measurements of microclimatic elements of the period from 2001 as compared with earlier investigations commenced in the second half of XX century. The characteristic of the cave microclimate includes information about the spatial distribution of microclimatic parameters, separation of climatic-ice zones and analysis of conditions of the occurrence of ice phenomena in the cave.

GENESIS AND MORPHOLOGICAL PECULIARITIES OF CAVE ICE DEPOSITS OF PRIOLKHONIE (BAIKAL REGION, RUSSIA)

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Priolhonie is situated in the central part of the western shore of Lake Baikal, geographical position is N 52°30′ – 53°30′ and E 106°20′ – 107°50′. 8 caves with snow and ice deposits are observed here: Mechta is the longest cave (823 m) and Ryadovaya is the deepest one (-57 m).

Ice cave observations stretch from 1976 to the present in the region considered. According to the origin of the coldness and accumulation of snow and ice the underground cavities can be divided into 3 main groups: 1. Cold caves (6 cavities) with a sack-shaped morphology are characterized by the descending winter type of air circulation. Formation of ice is due to the freezing of water which comes into cavity through the fissures, as well as forming from the air through the process of sublimation. In genesis they are congelation and sublimated ice. Snow-banks made as a result of accumulation of snow in underground cavities after snow-storms, as well as the falls of ice sublimated crystals are responsible for formation of snow-infiltrated ice, usually near the entrances. 2. Thermoventilated cave, having a few entrances, which is distinguished by the change of direction of air draught in the cold and warm seasons. Congelation and sublimated ice have been observed here and also snow-infiltrated ice. 3. Karstic pit, ice is formed as a result of recrystallization of the snow supplied to the cave through the entrance in cold period of the year (snow-infiltrated ice). Sublimated ice is fixed near the entrance.

In caves researched the following morphological types of cave ice deposits are occurred: congelation ice – droplet-accumulative aufeises, aufeis-layers, mantle of ice, ice of the lake, segregated ice; sublimated ice – hexahedral plates and snow-infiltrated ice – snow-banks.

Taking into consideration the genesis of cave ice and the morphological peculiarities of cave ice deposits the system of topographical signs for the presentation of the cave glaciation on the underground maps is proposed.

DOBŠINÁ ICE CAVE AFTER 136 YEARS

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Ice Cave named Dobšinská ľadová jaskyňa is occurred in the east part of Slovakia, in the southern part of National Park called Slovenský raj (Slovak Paradise) in the karst plateau named Duča. The Ice Cave was discovered by E. Ruffíny in 1870.

The Ice Cave is developed in Steinalm Limestones (Middle Triassic). It is a part of cave system of Stratenská jaskyňa Cave. Its length is 1483 m and from them 753 m is covered by ice. The underground glacier has own volume 110 thousand m^3 with maximum thickness 26.5 m.

The Ice Cave was created by underground flow Paleo Hnilec in late Tertiary. The main underground spaces belong to fourth cave developing level. We can to assume, that glaciated parts were developed through collapsing and disjunction the Ice Cave from Stratenská jaskyňa Cave in Mindel and beginning of the ice filling creation we can dating to Riss (250 –140 thousand years) at least. An accretion of the underground glacier is active from the top and from the bottom the underground glacier is defrosting, by this way the ice volume is changed by degrees.

In period of years 1998 – 2002 an expansive geological, geomorphologic and speleological research was realized in the Ice Cave and on the base of the research we obtain new view and opinion about genesis and development of the extraordinary interesting natural phenomenon.

The Dobšinská ľadová jaskyňa Ice Cave together with Stratenská jaskyňa Cave were in 2000 inscribed in to register of World Cultural and Natural Heritage of UNESCO.

ICE CAVES AS NATURAL ARCHIVES IN THE PALEOCLIMATIC STUDIES

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Ice deposits have a remarkable potentials to conserve climatic information. Ice cores give the most precise and direct records of some atmospheric parameters. These cores carry some evidences of the atmospheric composition and temperature changes that characterized part of the climatic history. Hypogean ice deposits make ice caves an interesting field of study. Problems that are encountered during the studies of hypogean ice deposits are quite different from that of "classical glaciology". To study this precious archive, both epigean and hypogean data should be incorporated. It is only by understanding the interactions of these two environmental conditions that is possible to give a significant paleoenvironmental interpretations. In this study, two different methods applied on two different systems of ice deposits are described. These are; the ice deposit of LO LC 1650 "Abisso sul margine dell'alto Bregai" in Moncodeno (Grigna Settentrionale, Italia), and the ice deposit of Fucul viu in Apuseni Mountains (Romania). Evolutional histories of these ice deposits are quite different, i.e., the LO LC 1650 is an endogenous ice deposit where as the Focul viu is an exogenous ice deposit. In case of the endogenous ice deposits, the "Stefan Problem" is applied and evaluated, in similar manner of the chilled small lakes, whereas possibilities of obtaining paleoclimatic information are evaluated thanks to the system of accumulation of snow in case of the exogenous ice deposit.

ICE CAVES SCIENTIFIC RESEARCH HISTORY: FROM LEONARDO DA VINCI TO THE END OF 1800

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One of the first descriptive notes of ice caves appeared in the note books of Leonardo da Vinci. The presence of hypogean ice deposits has always attracted famous scientists and illustrious travellers, which usually were informed by shepherds or local inhabitants, that rushed with curiosity to the ice caves to describe and to explain the hypogean glacial phenomena. In this work, references of of some of the most outstanding observations between the period of Leonardo da Vinci and the end of 1800 A.D. are cited. Two letters of Stenone (1671) wrote after his visits to two ice caves in the Northern Italy are reported in here in their original versions.

THE FIRST YEAR MICROCLIMATIC MONITORING DATA OF THE LO LC 1650 ICE CAVE (GRIGNA SETTENTRIONALE, LECCO, ITALY)

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Hypogean and epigean microclimatic monitoring systems were installed in Moncodeno (Grigna Settentrionale, Lecco, Italy) in October 2004. The epigean meteorological stations record every hour air temperature, air humidity, wind direction and velocity and global solar radiation. Within the cave air temperature was recorded in seven distributed all along the section of the ice cave, where as air humidity was recorded in three stations. Air direction and velocity was recorded in one station by an ultrasonic anemometer. Moreover rock temperature was recorded at two depths, 10 cm and 40 cm, and ice temperature on the surface. In this work data of the first monitoring year (October 25, 2004 – October 24, 2005) are presented. Epigean and hypogean data are studied and compared in relation to the seasonal variations. A conceptual model will be forwarded to explain the existing conditions manifested in the LO LC 1650 "Abisso sul margine dell'alto Bregai" Ice Cave.

CONTINENTAL ICE BODY IN DOBŠINÁ ICE CAVE (SLOVAKIA) – PART I. – PROJECT AND SAMPLING PHASE OF ISOTOPIC AND CHEMICAL STUDY

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The Dobšiná Ice Cave (Slovenský raj Mts., Slovakia) is of the static-dynamic type of cave whose icy masses have been formed and are being supplemented every year through natural cooling of the spaces during the winter season when cold air flowed and still flows through the higher situated opening into to the lower positioned spaces and cools the rocky walls.
Company HYDEKO-KV Bratislava received licence for drilling and sampling project in the Dobšiná Ice Cave from the Ministry of Environment of the Slovak Republic, Decision No. 5213/967/01-5.1 from 25 January 2002. The initiation and international background of the project was covered by the company SELOREEIG, Amsterdam, The Netherlands as a result of preparation of project proposal for EU funds competition. Technical aspects (drilling, sampling, and isotopic and chemical analyses) were solved mainly in co-operation with University of Copenhagen, Denmark.
So far no special measurements of the ice age were accomplished in the cave, so no representative data is currently available on the ice. Recently new evaluations of amoumt and distribution of ice masses in the Cave have been studied by modern geophysical methods (e.g. GPR-georadar measurements, up-dated morphometric measurements). In spite of some limitations of interpretation, the thickness of ice from 2.5 to 26.5 m was ascertained. The biggest thickness of ice was found in the Great Hall (26.5 m). 9,772 m^2 of total area covered by ice was evaluated. The volume of free space in the Cave was estimated as 33,921 m^3, while the volume of cave ice was 110,132 m^3.
The goal of this project was to analyse climate and environmental changes by detailed study of continental cave ice using isotopic methods and methods of chemical analysis. According to existing knowledge, it could be reasonably supposed that cores of cave ice from Dobšiná could add new information to the Holocene climate record of continental Europe. Changes of climate are closely related to changes in environment, so project results were supposed to be interesting from ecological point of view, as well.
Climate change studies would contribute to the attaining of commitments made by the EU in international treaties and agreements triggered by Global concern about the environment.

"A better formulation of environmental policies" (Kyoto Protocol 1997) can only be achieved when a better understanding of climate fluctuations, their causes and triggers is known. While an increase in global temperatures or 1-3 degrees over the next 80 years is calculated as a result of anthropogenic input (IPCC 1995), the rise is not higher than natural fluctuations, and so it is not clear if this will have any influence on the occurrence of climate driven abrupt changes. By studying the unique Dobšiná continental ice mass body, which can be calibrated against (sub)recent measurements, it may be possible to gain an insight into the potential effects.
The main steps of project solution were as follows:
preliminary sampling and testing analyses, selection of drilling sites
drilling, sampling, samples storing and transport
laboratory works and data interpretation.

PRELIMINARY SAMPLING AND "TESTING" ANALYSIS, SELECTION OF DRILLING SITES

Field works (excursion) with the aim to locate sampling places for „testing" samples and examine drilling conditions, to precise drilling sites locations and clarify sampling and samples procedures was accomplished by the "preparatory" working group of experts (J. Baker, S. Bo Hansen, K. Vrana) accompanied by Mr. Ľ. Očkaik, cave manager, Dobšiná Ice Cave, and Mr. M. Peško, hydrogeologist, Slovak Cave Administration, in March 8, 2002.
During the Cave excursion the "preparatory" working group agreed to take three testing samples of relevant volume from the "oldest" and "youngest" part of the continental ice. Three samples were taken in June 21 – 22, 2002 and analysed for isotopes, chemical elements and constituents in laboratories of the Copenhagen University. Testing samples were taken by Prof. Henrik Clausen and Steffen Bo Hansen from Copenhagen University, Kamil Vrana (HYDEKO-KV), Ján Zelinka and Ľubomír Očkaik (SCA).
The conclusion was that the best place for drilling (to reach the longest possible core profile), is the Great Hall.

DRILLING, SAMPLING, SAMPLES STORING AND TRANSPORT

The Dobšiná Ice Cave is accessible for a drilling rig. Collecting, sampling, and storing ice cores is a specialised task, which was undertaken by a specialised partner team. Only electric power was used for coring. Plastic materials were used and the drillers were aware of the problem of sterility of materials used for direct sampling. All materials used during coring were environmentally friendly. After coring the ice the relevant samples were immediately placed in special cold storage boxes and transported to the laboratory of the University of Copenhagen by car. The drilling was agreed in the Great Hall of the cave close to the ice body called the "Well". Drilling was accomplished in November 2002 by drilling rig developed especially for conditions of Dobšiná Ice Cave by Henry Rufli from the University of Bern, Switzerland.
Two boreholes were realised:
the first one to the depth 1.62 m (stopped by buried wooden pavement)
the second one to the depth 13.93 m (stopped by rock – ground?, boulder?).
The contribution will present all details about projecting, sampling, drilling, samples storing

and transport of Dobšiná Ice Cave samples, focusing on special technical conditions regarding drilling in so called "warm ice", and manipulation with samples before isotopic and chemical analyses.

Interpretation of results will be presented in the related symposium in the contribution K. Vrana, et al. "Continental ice body in Dobšiná Ice Cave (Slovakia) – Part II. – results of chemical and isotopic study".

CONTINENTAL ICE BODY IN DOBŠINÁ ICE CAVE (SLOVAKIA) – PART II. – RESULTS OF CHEMICAL AND ISOTOPIC STUDY

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This contribution continues information given in the symposium presentation K. Vrana et al. "Continental ice body in Dobšiná Ice Cave (Slovakia) - Part I.- project and sampling phase of isotopic and chemical study".

The main goal of this project is to investigate climatic and environmental changes by detailed study of continental cave ice using isotopic methods and methods of chemical analysis. According to existing knowledge we supposed that cores of cave ice from Dobšiná Ice Cave can add new information to the Holocene climate record of continental Europe. Changes of climate are closely related to changes in the environment, so project results are supposed to be interesting from an ecological point of view, as well.

The study encompasses continuous stable isotope (2H and 18O) and chemically analyses performed on samples from vertically drilled ice cores.

The stable isotope (δD, $\delta 18O$) records are obtained by mass-spectrographic measurements. The chemical analyses include the water soluble ions: Li^+, Na^+, K^+, NH_4^+, Mg_2^+, Ca_2^+, MSA, F^-, Cl^-, NO_3^- and SO_4^{2-}, and the concentration levels have been obtained by ion chromatographic measurements.

For crystal size determination several thin sections have been taken along the ice cores and the crystal sizes recorded.

A prerequisite for using the stable isotope and the chemical records in palaeo-climatic studies is a time scale, a depth-age relationship for the ice core. A simple time scale for the cave ice has been established based on ^{14}C dating of a bat buried in the ice, and transported by the internal movement of the ice, from the surface to the finding place some 2.5 m above the bottom of the ice.

The Dobšiná ice body represents a dynamic system at a temperature close to the pressure melting point.

The formation of the cave ice by various processes, like seeping and dripping groundwater, melting, refreezing, condensation and evaporation, has formed the ice into a laminated block of frozen groundwater. Since the cave was discovered in the late 1860'ies, comparison between old photos and drawings from the old times, and actual observations show the distance from the ice surface to the ceiling to be almost unchanged, meaning that the cave ice is in a state of equilibrium.

The ice of the Dobšiná Ice Cave provides a unique opportunity to study a climatic record preserved in a continental European setting. There are very few records of continental ice of

similar type. The interpretation of the stable isotope records in the sense of climatic information is not straight forward because the isotope ratios are affected by the high temperature and isotopic fractionation processes occur due to different processes like evaporation, melting and refreezing.
Also the chemical components are affected by various processes like recrystallisation and removal of easily soluble components from the ice.
The stable isotope ratios and the concentration levels of the chemical components in the laminated frozen ice body, are compared with today's precipitation values from the region of the ice cave. The stable isotope ratios and the chemical data are compared to the crystal size and the visual stratigraphy determined by light transmission.

SPATIAL DISTRIBUTION OF HIBERNATING BATS (CHIROPTERA) IN RELATION TO CLIMATIC CONDITIONS IN THE DEMÄNOVÁ ICE CAVE (SLOVAKIA)

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The Demänová Ice Cave ranks among the most significant ice caves in Slovakia by the character of glaciation. It is a dynamic cave of speleoclimatic aspect. It is one of the most important caves for hibernation of *Eptesicus nilssonii* and *Myotis mystacinus/brandtii* bat species in Slovakia. The hypogean and epigean climatic conditions of the Demänovská Ice Cave have been investigated continually since january 2002. Eleven data-loggers were located into unglaciated, temporary glaciated and permanently glaciated cave parts and closely to entrance and exit of the cave. One data-logger was placed in epigean environment in the vicinity of cave. Data loggers are acquiring a temperature, relative humidity and dew point data at intervals of one hour. At the same time also a chiropterological monitoring in the same parts of cave was carried out. Species composition, number of individuals and spatial distribution of bats circa at one month intervals during their hibernation period were observed. Bat community includes representatives of eight species, but only *Eptesicus nillsonii, Myotis mystacinus/brandtii* and *Myotis myotis* hibernate reguralry and in more numerous populations here. Rest five species are not suitable for our study. Results of monitoring show that each of three species prefer different cave parts, which are characterized by specific microclimatic conditions. We supposed that a choice of roost for hibernation have been influenced mainly by air temperature in this case. Aim of this study was to find to what extent the hypogean and epigean climatic conditions have an influence on the spatial distribution and local populations density of three bat species in the Demänová Ice Cave. In case the correlations exist, it could help us to define a range of temperature preference and tolerance for hibernation in each bat species in relation to thermodynamic zones of the cave.

POSTER PRESENTATIONS

CRYOMINERAL FORMATIONS FROM DOBŠINSKÁ ICE CAVE: PRELIMINARY REMARKS

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Some samples of cryomineral powder were collected in Spring 2004. The studied material was taken on the surface of ice glacier. Cryomineral powder was investigated under electronic scanning microscope Philips XL30. A morphology and a composition of cryo-crystals were studied.

The cryomineral formations from the Cave are compositionally very homogeneous. More than 99 % of material consist of calcite. Calcite crusts a millimeter-sized thickness are formed by botryoidal aggregates with spherule structure. The bottom part of these crusts is relatively flatted and on it the concentric building of spherule is well visible. On the top part micrometer-sized rombohedral heads of calcite crystals are observed.

The crystal's morphology and the look of their aggregates show that processes of their formation took place on the surface of ice. Formation of calcite crusts occurred on relatively flat substrate in the conditions of non-equilibrium crystallization caused by sharp changes of oversaturation in a thin layer of water (freeze-out or evaporation of solvent). Absence of skeletal forms of calcite points out that mechanism of calcite crystallization from capillary films characteristic for "warm" crystallization was not realized in this case.

The quantity of impurities in analyzed material is less than 1 %. Beside of organic matter there are magnetite and bolls of metallic Fe-Cr phases (likely anthropogenic genesis) observed in the mass of cryomineral crystals.

CAVE MICROCLIMATE RESEARCH PROGRAM

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The poster includes information about the assumptions and main research goals of the international cave microclimate research program, realised from 1998 in cooperation of the Institute of Geography and Regional Development of Wrocław University, Správa slovenských jaskýň, Správa jeskyní Moravského krasu and the Institute of Geography of Ruhr University in Bochum. Also, the poster presents basic information about caves included in the research and the research methods used with selected results of research papers.

SPELEOCLIMATOLOGICAL RESEARCH IN SLOVAK ICE CAVES

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The elaboration presents the scope and methodology of research work realised in two ice caves in Slovakia – Demänová Ice Cave and Dobšiná Ice Cave. The research has been conducted since 2002 within the scope of international research program on cave microclimate. Exemplary results of observations and measurements connected with research on the ice mass balance in the caves, the air exchange and the thermal structure of the caves have also been presented.

BOTTOM ICE IN DEMÄNOVÁ ICE CAVE – MASS BALANCE

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In spring (in May) 2005, the measurements of volume and surface of the bottom ice were first performed in Demänovska Ice Cave. They allowed the quantitative characteristic of the occurrence of ice in the cave. These measurements were repeated once again with the lapse of two months, which allowed demonstrating periodical changes in the balance of bottom ice in the cave. These measurements will be continued in the subsequent years. In connection with the results of research conducted parallel on the cave microclimate, their results are supposed to serve for the preservation of balance in the character of the cave icing.

SPATIAL DIFFERENTIATION OF THE AIR TEMPERATURE AND HUMIDITY IN ZRÚTENÝ DÓM (COLLAPSE DOME) AREA (DOBŠINÁ ICE CAVE)

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The poster is a presentation of results of research conducted since February 2003 in the area of Zrútený dóm (Collapse Dome) in Dobšiná Ice Cave. The research conducted there aims at the recognition of thermal structure and humidity in the zone of contact between the iced parts of the cave and those free from ice, and in the zone of potential contact between the cave and its surroundings (the karst collapse zone). As a result of the research conducted, the spatial distributions of the air temperature have been obtained for the seasons of the year as well as data about the thermal and humidity differentiation in the vertical profile of Zrútený dóm. These results have been compared with the results of the air movement recording in this area.

Remarks

Remarks

Silická Ľadnica ice cave
Photo: Petr Hipman

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