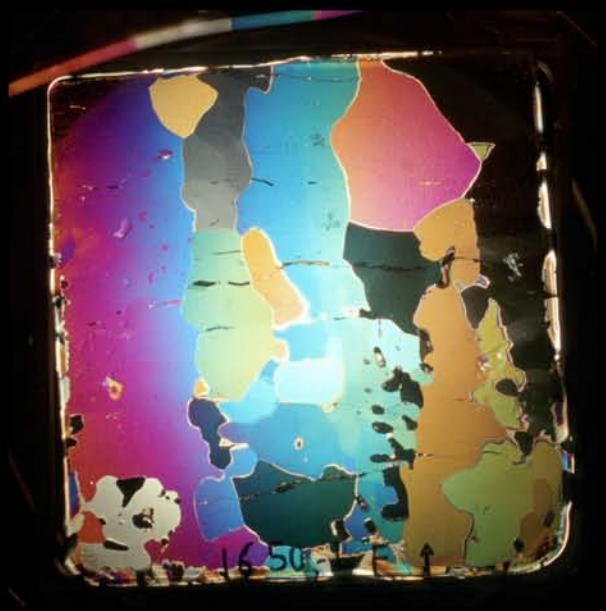

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IWIC-I

1st INTERNATIONAL WORKSHOP ON ICE CAVES - CĂPUŞ, ROMANIA - 29 FEBRUARY - 3 MARCH 2004

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

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Speleological Institute "Emil Racoviță" Cluj Department

UNIVERSITÀ DEGLI STUDI DI MILANO BICOCCA
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UIS - GLACKIPR
Glacial Caves and Cryokarst in Polar and High Mountain Regions Commission

1st International Workshop on Ice Caves

VOLUME OF ABSTRACTS

Căpuş and Scărişoara (Romania)

29th February - 3rd March 2004

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VOLUME OF ABSTRACTS

Edited by

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- Ice stalagmites in the Gheţarul de la Scărişoara Ice Cave (M. Citterio)

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FOREWORD

As you know, ice caves represent a small but fascinating research field for speleologists and glaciologists in many countries. As you also know, the interested scientific community is quite small and scattered. IWIC-I is the first workshop entirely devoted to ice caves research. We wish to offer a place to point out the state of the art, to discuss ongoing research projects, and to boost future international co-operations.

Just to avoid confusion, IWIC-I will focus on "ice caves" in the meaning of rock-hosted caves containing perennial ice and snow deposits.

Furthermore, IWIC-I is an ideal opportunity to widen the availability among the interested audience of important research results formerly published only in non-English papers.

The day following to the contributions presentation session there will be a field excursion to the Gheţarul de la Scărişoara, one of the most documented ice caves in the world.

We hope you will enjoy the meeting and the field trip!

Sincerely yours,

Prof. Bogdan P. Onac

Prof. Alfredo Bini

ORAL PRESENTATIONS

GIS ANALYSIS USED FOR DETERMINING THE OCCURRENCE OF ICE-CAVES IN PIULE-IORGOVANU MOUNTAINS

Ardelean M.

West University of Timişoara, Department of Geography, B^{dul} V. Pârvan 4, 300223 Timişoara, Romania.

This paper has as aim to determine the possibility of ice caves occurrence in Piule-Iorgovanu Mountains by using the facilities offered by GIS analysis. In the first part it will be made an analysis on few known ice caves, in terms of existence conditions, like altitude, slope and aspect, rainfall quantities. In the second part these data are introduced and used by GIS analysis in order to obtain a series of logical maps for each element that controls the development of these features. Finally, by overlaying these maps, we will be able to obtain the possible area of ice caves occurrence.

AGE AND EVOLUTION OF TWO CAVE ICE DEPOSITS IN THE BRENTA DOLOMITES (ITALIAN ALPS)

Borsato A., Miorandi R. & Onelio F.

Museo Tridentino di Scienze Naturali, via Calepina 14, 38100 Trento, Italy.

We discuss the morphology and evolution of two important ice deposits from alpine caves in the Brenta Dolomites (Italian Alps). Grotta del Castelletto di Mezzo opens at 2400 m a.s.l. and consists by a complex network of meanders that lead, through a 20 m-deep shaft, to a 30 m-wide chamber. This room host the most important stato-dynamic glacier of Brenta Dolomites, a 22 m-thick stratified deposit, which at present is cross-cut by a eddy carved by dripping waters and air flow. Grotta dello Specchio opens at 1930 m a.s.l. and consists of a single gentle downdipping gallery interrupted, 30 m from the entrance, by a 25 m-deep shaft. At the base of the shaft is present a 4 m-thick stratified ice deposit, which at present is cut by a large kettle-hole carved by the air current that flow from the inner part of the cave. Tritium analyses from Grotta del Castelletto di Mezzo samples and the measurement of the ice strata thickness allow to determine that most of the ice deposit formed between 1500 and 1980's. From the late 1980's, the net annual ablation exceeds the accumulation and the thickness of the deposit begins to diminish. During the 1997-2003 period the measured net annual ablation varied between 9 cm/year (Grotta dello Specchio) and 20 cm/year (Grotta del Castelletto di Mezzo) and increased exponentially in the last three years.

OBSERVED TRENDS IN THE CHEMICAL COMPOSITION, $\delta^{18}O$ AND CRYSTAL SIZES VS. DEPTH IN THE FIRST ICE CORE FROM THE "LOLC 1650 ABISSO SUL MARGINE DELL'ALTO BREGAI" ICE CAVE (LECCO, ITALY).

Citterio M.[1], Turri S.[1], Bini A.[1] & Maggi V.[2]

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A stratified, clear ice deposit was drilled in ice deposit found in a cave opening at 2030 m a.s.l. in the Moncodeno area (Grigna Settentrionale, Lecco, Italy), and 1.20 m of ice core was recovered. Due to the topography of this cave the snowfalls cannot reach the ice deposit that is located at a depth of 80 m below the cave entrance. Measured samples from the ice core show well-defined general trends both in the $\delta^{18}O$ values and major ions (Na^+, K^+, NH_4^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, NO_3^-). Thin sections cut along the whole length of the core also show significant textural evolution from equidimensional centimetric at the top to columnar pluridecimetric crystals near the bottom of the thickest stratum. We argue that the observed features are compatible with a "freezing shallow lake" genetic model, even though local deviations from the main trends can be observed at certain depths.

MULTIDISCIPLINARY APPROACH TO THE STUDY OF THE LO LC 1650 "ABISSO SUL MARGINE DELL'ALTO BREGAI" ICE CAVE (LECCO, ITALY)

Citterio M.[1], Turri S.[1], Bini A.[1], Maggi V.[2], Pini R.[3], Ravazzi C.[4], Santilli M.[1], Stenni B.[5] & Udisti R.[6]

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In 1999 we selected the LoLc 1650 "Abisso sul Margine dell'Alto Bregai" ice cave to be a test site for a large number of different studies dealing with both ice caves climatology and cave ice glaciology. To allow for a cross dating of wood chips possibly to be found in the ice, and to investigate the dynamics of the vegetation cover outside the cave, we constructed a local 850 years long *Larix decidua* Miller growth curve. We performed air temperature recordings both inside and outside the cave, and described the surface morphology and internal structure of the fossil, stratified, clear ice deposit found at a depth of -80 m below the cave entrance. On ice samples 5 cm thick cut from a 1.20 m long ice core we determined chemical composition, $\delta^{18}O$, pollen content and atmospheric dust counting. We also cut thick sections for the morphological description of fluid inclusion and thin sections for textural and universal stage studies. Many of these investigations are still in progress. In this paper we summarize the results attained thus far and we show that the integration of data coming from different disciplines is the fundamental step in the study of ice caves and cave ice. This stresses the importance of a collaborative effort among researchers in different fields and institutions.

WHEN AND HOW MUCH ICE IS FORMED AND/OR MELTED INTO GLACIER CAVES

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Air circulation in englacial and subglacial caves was investigated. Thermodynamic conditions in these caves are described and analyses of different cases appearing in the nature as well as their morphological consequences are presented.

The enthalpy-entropy diagram allowing the calculations of both glacier internal melting and, in the case, icing formation as well as temperature drops which could have occurred during these processes are described. Two representative examples: from Alfred Wegener Glacier (investigated during "Groenlandia 90" Expedition) and from the Grise Fiord Glacier, Ellesmere Island ("Norte Magnético 91" Expedition) are included.

The quantitative calculations of the glacier internal melting represent a contribution to the knowledge of the polar ice sheets mass balance, tightly related to the global changes.

ENVIROMENTAL ISOTOPE STUDY ON PERENNIAL ICE IN THE FOCUL VIU ICE CAVE, BIHOR Mts. ROMANIA

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Usually caves are ideal places to protect objects for very long time. The reasons are: rather stable temperature and humidity, very small-scale erosion, negligible anthropogenic disturbance. Some physical and/or chemical characteristics of objects remained in caves have a lot of information about the conditions they formed in.

Perennial ice block, including subfossil wood, can be found in the Focul Viu Ice Cave. Hence there is only very limited information on the process of ice formation, age of ice, growth rate of ice, we have made stable oxygen isotope and tritium measurements on ice samples (mostly drill core samples), and radiocarbon age determination has been carried out on two wood samples from different depths of the ice block.

Using a manual corer a 7.27 m long ice core was taken from the ice block situated in the main hall of the cave. The ice drill-core was cut into 300 pieces on the spot. Mass spectrometric oxygen isotope ratio measurements ($\delta^{18}O$) were made on 152 samples.

There is an indirect linear correlation between the monthly mean $\delta^{18}O$ value of the precipitation and the monthly mean temperature of the air. Precipitation fallen in the winter- and spring-time takes place in the formation of the ice in the ice cave, so the $\delta^{18}O$ series of the ice core may reflect the change in the mean air temperature of the winter-spring periods of particular years. $\delta^{18}O$ values range between -8.19 ‰ and -12.3 ‰ suggesting about 11 ºC difference between the maximum and minimum mean temperatures of the represented period.

The radiocarbon ages of the two wood remnants taken from different depth (6.67 m and 11.1 m) in the ice block imply a long term growth rate of 0.85 cm/y for the ice, while tritium data indicate a 2.7 cm/y short term growth rate. This big difference between the long and short term growth rates confirms the theory that on long time span (few hundred years) there are periods when the balance of ice growth is negative, more ice melts than forms. This inference is supported by the dark impurity (horizontal) layers distributed unevenly along the vertical profile, because these layers were probably formed as results of ice-melting periods. It suggests that the $\delta^{18}O$ values of the sampled ice core do not show the continuous climate change, but the $\delta^{18}O$ series between impurity layers can be regarded as windows to certain time periods. The next step is to determine which periods are represented by these $\delta^{18}O$ intervals; dendrochronology may help us.

AN ANALYSIS OF THE FORMATON AND EVOLUTION OF THE SCĂRIŞOARA ICE CAVE, ROMANIA

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The Scărişoara Ice Cave is preserved due to permafrost conditions in the cave. The temperature of the ice is basically governed by the winter cold, and only to a minor extent influenced by summer temperatures. A rock slide in the past is believed to have changed the local climate in the cave to such an extent that the average annual mean temperature is well 7 degrees lower than in the surroundings. At present the ice block is slowly thinning, but the present day climate is sufficiently cold to preserve permafrost conditions at the base of the ice. Earlier warm periods over the last 3000 years may have caused warming of the base of the ice block and thus caused subglacial melting. The local climate in a cave differs significantly from free air situations as the warming is rather geothermal heat flux and latent heat than sensible heat which normally is limiting factor on glacier extent. In February 2003 a 22 metre ice core was sampled in the centre of the ice block. The core indicates a more or less constant growth phase of the ice. Approximately 400 sedimentary layers have been identified by visual examination. In the clear stratification only few hiatuses are found. Ice crystallographic analyses indicate a steady growth of ice crystals with depth and there is no sign of deformation. We have not been able to execute any dating of the core this far. Carbon-14 dates from a close by section support a more or less steady growth of the ice block until the mid 20th century. However, a vertical exposure of the ice may indicate a past basal melting phase prior to the Little Ice Age.

LATE HOLOCENE ENVIRONMENTAL CHANGES AT GHEŢARU DE LA FOCUL VIU (BIHOR Mts, ROMANIA) STUDIED BY VARIOUS METHODS

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Gheţarul de la Focul Viu is the second largest ice cave of Romania. There is a mixed deciduous/coniferous forest surrounding the cave. From fifteen Norway spruce *(Picea abies),* five silver fir *(Abies alba)* and eight beech *(Fagus sylvatica)* trees were bored by increment corer. There are numerous trees fallen into the cave through an opening in the ceiling of the main hall. Thirty-seven disks were sawn from stems from the ice surface down to the base of ice. Following standard preparation methods separate chronologies are developed for conifer and for beech.

For dating the age of the upper ice layers tritium contents were measured in three depth intervals. Tritium concentration suggests that ice at 50 cm depth accumulated between 1983 and 1988.

A 7.27 m long core was taken from the ice body filling the lower half of the main hall. The core was cut to samples 2–8 cm long immediately after coring. Oxygen isotope ratios of 152 samples were analysed. $\delta^{18}O$ values of the Gheţarul de la Focul Viu ice core range from -11.56 ‰ to -8.19 ‰. It suggests an oscillation of about 9º C for the winter-spring mean temperature during the last millennium.

A wood remain taken from the ice core at 6.67 m depth was dated 850±50 (BP) (cal AD 1160-1260), while a branch at 11.1 m depth is 1230±40 (BP) (cal AD 720–730 or 750–870) years old.

Melting periods destroy a particular part of ice block and a few millimetres thick impurity layer remains from the melted ice strata. Melting occurs when the external climate changes warmer and/or more humid providing better condition to vegetation growth. The growth change pattern of conifers implies unfavourable condition during the second half of 1980's, 1920–1940 and 1845–1895. High ring-width indices correspond to sections where impurity layers concentrate. Using this connection the index curve of ring-width, reflecting growth changes, can contour the age of particular intervals of $\delta^{18}O$ series.

WHAT HEAT FLUX MUST BE CONSIDERED AT THE BASE OF AN ICE CAVE?

Luetscher M. & Jeannin P.-Y.

Swiss Institute for Speleology and Karst Studies, CP 818, 2301 La Chaux-de-Fonds, Switzerland.

Conductive heat exchanges with the surrounding rock represent an important heat supply for the energy balance of an ice cave. Our conceptual model of temperature distribution in karst environments demonstrates that air circulations can largely dominate water infiltrations in the karst vadose zone. Temperature gradients within this zone will therefore be usually close to humid air adiabatic lapse rate (~-0.5°C/100 m). Measurements carried out at Monlési Ice Cave enable to assess the resulting heat fluxes in accordance with ice age estimations.

ON THE ROLE OF AIR CIRCULATIONS FOR THE PRESENCE OF SUBSURFACE ICE FILLINGS: AN EXAMPLE FROM MONLESI ICE CAVE (SWITZERLAND)

Luetscher M. & Jeannin P.-Y.

Swiss Institute for Speleology and Karst Studies, CP 818, 2301 La Chaux-de-Fonds, Switzerland.

Investigations carried out in Monlési Ice Cave outline the presence of important air circulations during winter season between the two main cave entrances. Air velocities measured in a known cross section enabled to assess a maximal air flow of more than 10 m^3/s. The resulting annual heat exchange is expressed by the temperature difference between inflow and outflow. It is demonstrated that air circulations play a major role on the final energy balance.

ABOUT DEGRADATION OF GLACIATION IN KUNGUR CAVE AND POSSIBLE WAYS OF ITS RESTORATION

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[2] Mining Institute, Ural Section, Kungur laboratory, Russian Academy of Sciences, Perm.

We present a general overview of the Kungur ice Cave (Perm region) and the history of the scientific studies performed in it. We also give a report of the ice dynamics with respect to the anthropic interventions made on the Kungur Ice Cave. Already in 1984-1985 cave ice mass balance was negative and the quantity of ice accumulated in the cave during winter was approximately three times less then the quantity of ice melting in the summer. We discuss some possible interventions that could help in preserving the ice formations and the reasons for their implementation.

MINERALOGICAL AND URANIUM SERIES DATING STUDIES IN SCĂRIŞOARA ICE CAVE (BIHOR MOUNTAINS, ROMANIA)

Onac B. P.

Quaternary Research Group, Dept. of Mineralogy, University of Cluj, Kogălniceanu 1 & Speleological Institute "Emil Racoviţă", Clinicilor 5, 400006 Cluj, Romania.

Recent mineralogical investigations carried out in Scărişoara Ice Cave pointed out the presence of speleothems made up of monohydrocalcite and hydromagnesite. Although both minerals were documented earlier from other Romanian caves this is for the first time when a speleothem is entirely composed of monohydrocalcite. Crocoite, a rare mineral was also identified, but it is not a real cave mineral being transported into the cave by the percolating waters. Alpha and TIMS U-Th dating of some speleothems from Scărişoara Ice Cave enabled us to identify the most prominent climate events over the last 500,000 kyr in the vicinity of the cave and also to estimate a mid- or even low Pleistocene age for the cave speleogenesis.

SCĂRIŞOARA ICE CAVE: A BIOLOGICAL EXTREME ENVIRONMENT

Racoviţă G.

Speleological Institute "Emil Racoviţă", Cluj Dept., Clinicilor 5, 400006 Cluj, Romania.

Within the Gheţarul de la Scărişoara, it is notable that the components of the underground terrestrial community are influenced by strong microhabitat selection. The community includes troglophilic and troglobitic representatives of three groups: araneids (*Nesticus racovitzai* and *Troglohyphantes racovitzai*), springtails (*Onchopodura crassicornis, Onychiurus* spp., and *Tomocerus minor*), and leptodirine beetles (*Pholeuon* (s. str.) *proserpine glaciale*). The first two groups are found only sporadically, and the community is dominated by the beetles which, being quite numerous, are amenable to ecological research. However, the specific dwelling-place of these beetles overlaps only those deep parts of the cave without ice deposits.

The dynamics of *Ph. p. glaciale* population is controlled by the environment conditions (mainly air temperature). In the periglacial part of the cave where negative temperatures are recorded during the winter, the size of the local populations is exclusively controlled by this physical parameter. As a consequence, a clear seasonal variation was observed, the beetles completely disappearing during the winter. By contrast, in those parts of the cave where the temperature does not vary seasonally but is always above 0ºC, the beetle's population is permanently present. In this environment the local population density is controlled by a self-adjustment phenomenon and the ecological periodicity in the reproductive cycle.

THE St-LIVRES ICE CAVE: ATTEMPT TO RELATIVE DATING OF FIRN ACCUMULATION WITH DENDROCHRONOLOGICAL METHODS

Schlatter F.

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Located at 1359 m a.s.l. on the south east side of the Swiss Jura range (Bière/VD, 6°17'50''/ 46°33'47''), a collapsed doline with a diameter of about 40 m acts as an important source of snow accumulation during the winter season. The particular morphology and the sufficient deepness (-45m) of the cavity enable the trapping of cold air. This causes the freezing of infiltration water and the transformation of the snow into ice. Ice flows along about 40 m, leading to the lower part of the cavity. In this place, an overhanging ice wall forms the front of this small glacier. Thus, it is possible to observe an almost continuous outcrop of the glacier. The presence of organic matter in the ice allows an identification of different layers. Moreover, an important number of branches and trunks are trapped in the ice.

This study aims to date (relative age) ice layers with woody material. Dendrochronological methods are used to cross date the single layers containing subfossil tree trunks and branches. Analysis of living trees outside the ice cave will create the link between the living and the subfossil samples, permitting an absolute dating of the trapped trunks. This work is expected to deliver important data on the process of firn accumulation in ice caves and the causes of the important ice melting of the 20 last years.

SEASONAL, ANNUAL AND DECADAL ICE MASS BALANCE CHANGES IN JASKINIA LADOWA W CIEMNIAKU (ICE CAVE IN CIEMNIAK, TATRY, POLAND)

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Jaskinia Ladowa w Ciemniaku (Ice Cave in Ciemniak) is located in the Western Tatra Mountains (Tatry Zachodnie). It hosts the largest known subterranean block of perennial ice in Poland. Its entrance is located at 1715 m a.s.l and the cave climate is classified as dynamic type with seasonal and diurnal variations of air temperature. The mass balance of ice body was investigated on monthly, annual and decadal scale through a set of detail measurements of ice geometry performed during 2000-2002 years and comparison with existing older data. The background of recent perennial ice changes was demonstrated through temperature measurements and seasonal ice surface observations. In general the ice mass reveals negative mass balance, however the melting is not continuous throughout the year. The largest lowering of ice surface was observed in summer and in winter (when the temperatures were well below zero) – due to sublimation. The increase in ice volume was observed in springtime when percolating water was available and the temperature was slightly below zero. In the year 2000-2001, 37.5 m^3 of ice was lost and in 2001-2002 as much as 62.5 m^3. Comparison between the detail geodetic survey in 2002 and in 1986 reveals that the averaged annual ice volume lost was 36.6 m^3y^{-1}, so slightly less than recently. The comparison of ice mass geometries in 1922, 1950 and 1986 allows to estimate averaged annual ice mass loss in the period 1922-1950 as 23.0 m^3y^{-1} and in the period 1950-1986 as 24.8 m^3y^{-1}. It clearly shows that ice mass losses were significantly higher in the last decade.

PRELIMINARY ANALYSES OF THE AVAILABLE HYPOGEAN AND EPIGEAN TEMPERATURE RECORDINGS IN MONCODENO (GRIGNA SETTENTRIONALE, LECCO, ITALY)

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The climatic study of ice caves in Moncodeno is one of the aspects of a multidisciplinary project aimed at the understanding of processes acting in the formation and conservation of ice in caves. The hypogean climate is the most important factor in controlling the formation, conservation and ablation of cave ice. In Moncodeno since 1999 four small data logger are acquiring air temperature data at intervals of three hours. Two data loggers were set up in the LO LC 1650 “Abisso sul Margine dell’Alto Bregai” and in the LO LC 1592 “Dolina con laghetto ghiacciato” ice caves. Two data-loggers were set up in the epigean environment. In this work we illustrate the influence of epigean temperatures on the recorded hypogean temperatures.

PRELIMINARY EVALUATION OF A STEFAN PROBLEM - LIKE APPROACH IN THE INTERPRETATION OF THE PHYSICAL CONDITIONS OF SHALLOW FREEZING LAKES IN THE LO LC 1650 "ABISSO SUL MARGINE DELL'ALTO BREGAI" ICE CAVE (LECCO, ITALY).

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Previous studies on the ice block found in LO LC 1650 “Abisso sul Margine dell’Alto Bregai” indicates a genesis of the ice layers compatible with a “shallow freezing lake” model. The ice block appears to have formed through the superposition of ice layers produced by the repetition of this freezing mechanism. Melt water from the epigean snow cover and meteoric water were the primary supplies in the formation of these shallow epigean lakes. Water entering the cave and collecting on the top surface of the ice block found an environment with physical conditions favourable to the liquid-solid phase change. In this paper we have evaluated the suitability of a Stefan Problem modelling in the interpretation of the temporal and thermal conditions of the freezing process. We have computed Stefan Problem solutions using published ice constants and data coming from our previous studies on the LO LC 1650 “Abisso sul Margine dell’Alto Bregai” Ice Cave.

ICE CAVES AND PERMAFROST

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The paper will examine the relation between the ice caves and permafrost, looking at the Romanian karst situation where about 40 caves with ice and perennial snow are known.

The permafrost is defined as ground (i.e. soil and/or rock) which remains at or below 0ºC for at least two consecutive years. Taking into account the significance of this definition and the presence of the ice bodies in the caves, we consider that these are, in the climatic characteristics of the temperate zone, a particularly form of sporadic permafrost or extrazonal permafrost. The genesis of the ice masses in the caves is connected with the microclimatic local conditions.

The spreading of ice caves is analyzed in correlation with altitude, freezing and thawing indexes, and with continentality index.

SCĂRIŞOARA (ROMANIA), EISRIESENWELT, AND DACHSTEIN (AUSTRIA) ICE CAVES: A PRELIMINARY COMPARATIVE STUDY

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Authors have studied the Scărişoara Ice Cave for over 20 years. In the early 90' they have also carried 2 years climatologic researches (measurements of outside and inside temperature, humidity and air ventilation) and ice dynamic investigations on Eisriesenwelt and Dachstein caves. Pollen studies were also undertaken. The present paper aims to answer the following problems:

1. Why the ice kept in the three caves has different ages (Scărişoara) (3,500 yrs) and the two ice caves from Austria (500 yrs).
2. The way the presence of tourists influences the ice deposit.
3. How can be stopped the annual decrease of the ice volume
4. How the geographic settings of the three caves contribute to the conservation of the ice deposits.
5. What is the future of ice deposits in the investigated caves.

ON SUSTAINABLE MORPHOLOGY OF THE SNOW PATCHES IN FĂGĂRAŞ MOUNTAINS - SOUTHERN CARPATHIANS

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The snow patches as they are known in the specialty literature, like: *snow patches*-english language, *depositi nevosi*-italian language, *dépots nivals* or *placages neigeux*-franch language, *Schneeflecken*-german language, have not been the research issue in our country. In the countries of tradition in snow research they are investigated by glaciologists and geomorphologists. Our singular study in the domain is a preliminary one and refers to those characteristics of the subnival morphology.

We have investigated 2 representative areas: one placed on the Arpăşel Ridge on the Southern Slope, ovelaing a huge structural escarpement, the other being placed in the upper part of high mountain avalanche culoir in Pietroasa Doamnei Glacial Cirque on the Northen Slope of the massif. Both areas are placed in the central glacial sector of highest massivity at an altitude of over 2000 m beyond the 0° C isotherm that is placed at about 2050 m.

From the point of view of the morphoclimatic position the 2 areas are in the periglacial level, the sublevel of the complex periglacial processes thermally framed between 0° C and -3° C.

The snow patchs are the expression of the great snow falls but also of the winter and spring avalanches that generate such very large thicknesses of the snow layer. They are individualized starting in May and persist longer till the late July or August and sometimes till the new snow falls in September. All over this season they modify their size and shape under the impact of the daily and monthly variations of the thermal regime. The melting waters are creating real small caves unde the snow.

The subnival geomorphology „extremely spectacular" but very changeable, combines a series of shapes and microshapes of plateau and wall: flows, columns, draperies, siphons, spoon-shaped forms, positive landforms of residue relief.

An important role in the making of the shapes is played by the air that circulates especialy in the so called pseudorimayé but also inside the snow patches, influenced by subnival micromorphology. All shapes have an ephemeral life passing from one form to another or simply dissapearing.

We consider that a detailed study on a perioud of many years would offer new data on the evolution and subnival morphology but also on some high mountain relief modelation processes. At the same time the snow patches can be indicators of the periglacial mountain climate in the present context of the global climate changes.

PERMAFROST AND INTERSTITIAL ICE IN THE PERIGLACIAL DEPOSITS OF PARÂNG MOUNTAINS

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In the periglacial area of Parâng Mountains the deposits like debris form some periglacial landforms like talus cone and protalus rampart, stone rivers, stone banked tongues, block fields and rockglaciers. When the debris is accumulated in shadowy areas, snow, firn and ice can persist all the year round in the periglacial landforms. This can be discovered by making direct observations in the deposit, drillings and other simple methods like the BTS method in winter time and the temperature measurement of the springs in summer time. Besides those classic methods used to discover the permafrost and interstitial ice, firn and snow, we developed a prediction method that use the digital models based on some of the periglacial environment variables (slope, aspect, temperature, altitude).

SLOW AIR MOVEMENT IN THE DOBŠINSKÁ ICE CAVE, SLOVAKIA

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Selected results from the whole-year registration of slow air movement in the Dobšinská Ice Cave are presented in the paper. The beginning of the present research of cave air circulation processes in July 2002 is linked to the previous works, realized through 1980–1984. Up to date acoustic thermo-anemometers are used in this research. They enable acquisition of new, detailed qualitative and quantitative information on the course and character of the pursued phenomena. Considering the volume of the cave, complexity of the registration, space and time changes in the air movement structure, the continuous monitoring will proceed also in the next four years. The research is a part of a complex international program aimed at the study of the dynamics of climatic processes in caves with different characteristics of the environment.

POSTER PRESENTATIONS

CRYOMINERAL FORMATIONS FROM NORTH BUKOVINIAN CAVES

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Underground glaciation implying multiannual cave glaciers is a prominent feature of caves from northern regions, as well as from mountain areas. While moving to the south the period of presence of infiltration waters in the form of flow ice becomes shorter.

The Northern Bukovina at 47-48° lat. N, is an area where glaciation of caves located elsewhere than the mountains has only *a* seasonal nature.

The freezing-out of a mineral component from water solutions is connected to glaciation processes. The high mineralization of infiltration waters, which is characteristic for caves, especially the ones in gypsum, as well as periods with low temperatures, are necessary for cryogenic freezing-out and accumulation of "solid residues" from water solutions. In northern regions cryomineralogenic process differ by simplicity and a relative constancy. In more southern areas, recurring thawing under conditions of temperature fluctuation around the zero value causes essential complications in the processes of crystallisation, accumulation and aggregation of the frozen-out material.

Investigations of the cryomineral *aggregates* were carried out in two large gypsum caves: Bukovinka (5155 m length) and Pionerka (530 m). Among caves of Northern Bukovina, these caves show the largest amount and variety of seasonal ice formations.

From a morphogenetic viewpoint, the underground ice is represented by stalactites, draperies, stalagmites, column-icefalls, ice flowstones. In some cases, cave hoarfrost (sublimation ice) is generated on the cave ceilings. Direct observations in caves allowed us to establish that the cryomineral substance coming out on a surface of ice formations, and also remaining after their thawing, is characterised by a considerable aggregate variety. The Pionerka Cave, peculiar in terms of lengthened period of thawing of ice formations, and also of cyclicity of freezing - thawing processes, is especially indicative in this respect.

Among discovered and investigated cryomineral aggregates we mention gypsum powder, gypsum flour, gypsum films, gypsum milk and gypsum paste. The majority of the cryomineral aggregates discovered in Bukovinian caves are stacked in thermodegradation *series*, *i.e.* they represent consecutive stages of cryogenic material aggregation on the background of ice thawing of "parent" substratum. The examples of such *series* in case of ice stalactites are *powder* ⟶ flour ⟶ film, while in the case of ice stalagmites, powder ⟶ flour ⟶ milk ⟶ paste. Naturally, weather

changes and seasonal climatic cycles (refreezing-in, drying) confuse the simple schemes up to the occurrence of "time-returning" elements.
In the structure of cryomineral formations from Bukovinka and Pionerka caves, the series of mineral kinds of autochthonous (cryogenic) and allochtonous (first of all, aerosol) origin was determined. The autochtonous part of cryogenic material consists mainly of gypsum, celestine and calcite. The allochtonous material is represented by a significant amount of impurities postponed on surface of seasonal ice by gravitational and air-aerosol ways. There are: clay particles, heavy minerals, ferriferous particles of technogenic origins and even, presumably, cosmic dust particles.

GLACIAL ABLATION FORMS IN THE DOBSINA ICE CAVE

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The Dobsina Ice Cave (Slovak Paradise National Park, Spis-Gemer Karst) is one of the most important ice caves in the world. The altitude of its entrance is 969 m a. s. l. Its ice parts are 920 – 950 m a. s. l., below an alpine zone. The ice fill in the cave occurs in several forms: floor ice, icefalls, ice stalagmites and columns. The surface of ice fill is 9,772 m^2; its volume is 110,132 m^3. The maximal thickness of floor ice is 26.5 m. From 2000, the Dobsina Ice Cave is included in the World Heritage (in the framework of the extension of Slovak-Hungarian site *Caves of Slovak and Aggtelek Karst*). Several glacial ablation forms in the cave are formed in consequence of water seepage from melting snow and rainfalls, and also in consequence of air circulation and convection, and of the development of tourism in the cave. Supraglacial ablation features present physically produced forms (ablation dripping-related pits, potholes, and depressions, ablation pinnacle karren, ablation kamenitzas, ablation rinnenkarren, ablation outflow channels from dripping-related depressions, large sublimation scallops on ice walls, melting depressions near electric lights) and mechanically produced forms (artificial notches of tourist path in the floor ice, artificial outflow channels). Similarly, intraglacial ablation forms consist of physical forms (sublimation scallops and flutes on ice walls of artificial tunnels in the ice mass, melting ceiling cupola above the electric lights in the artificial small hall inside the ice mass) and mechanic forms (artificial tunnels in the ice mass). Intraglacial and subglacial ablation phenomena produced by running water are not known in the cave.

DOBŠINSKÁ ICE CAVE – THE LOCALITY OF THE WORLD HERITAGE

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The poster presents the Dobšinská Ice Cave as one of the most significant ice caves in the world, which in Europe is emphasized by its location outside the Alps region. The underground ice monolith lies at an elevation from 920 to 950 meters above the sea level. The surface covered by the glacier reaches 9,772 square meters, with an ice volume of about 110,132 cubic meters. The greatest thickness of ice is 26.5 m. This cave is genetically part of the Stratena Cave System, which is the second longest one in Slovakia. Other then for the unique natural conditions, the Dobšinská Ice Cave is also known for its rich history. It has been opened for tourist access since 1871 and one of the first electrically illuminated caves in the world – since 1887. The cave is a property of the Slovak Republic and as a natural monument it is subjected to the highest standards of protection. In November 2000 it was listed among the World Heritage objectives of UNESCO.

ICE DEPOSITS IN THE BRENTA DOLOMITES CAVES (ITALIAN ALPS)

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The Brenta Dolomites are located in Western Trentino (NE Italy). This work shows the current state of the cave ice deposits knowledge, with a description of the most important deposits, and some morphological aspects. We analyse more than 100 caves, most of which are single superficial shafts, which developed between 1900 and 2750 m a.s.l., with a maximum concentration (>50%) between 2300 and 2500 m a.s.l. Most of the deposits are simple firn cone deposits, and only four caves host significant stratified ice deposits, with a maximum thickness of 22 m. Usually the ice deposits are located near the cave entrance, at a depth of -10 m (Grotta alla Bocca di Brenta), –20 m (Grotta dello Specchio), –50 m (Grotta del Castelletto di Mezzo) and -160 m (Abisso dello Statale) with respect to the entrance. All the deposits seem to be fed by several different trickles, but at present the summer-autumn melt strongly exceeded the amount of ice formed during short periods in the late winter.

A NEW CLASSIFICATION PROPOSAL OF ICE CAVES

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Former investigations of ice caves have shown that subterranean ice fillings might result from different processes. Synthesizing the published material reveals however a large confusion in the existing nomenclature of ice caves.
A new proposal for their classification is proposed in accordance with previous researches. This classification is primarily based on climatological criteria (air trap versus chimney effect) but also includes ice formation processes (firn accumulation versus congelation ice).

SEASONAL PATTERNS OF CAVE ICE ACCUMULATIONS: AN EXAMPLE FROM THE PINEGA GYPSUM KARST (RUSSIA)

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Located in the arctic Russia, the Pinega gypsum karst has an extensive cave system which is currently being explored by speleologists from Arkhangelsk and Moscow. During warm season, conduits are subject to important water circulations and are partially or completely flooded. In winter, strong air circulations are induced by the numerous entrances to the system. These characteristics, makes it an ideal place for the observation and description of different types of cave ice. Evapo-condensation processes are particularly well evidenced by the numerous forms of hoarfrost deposits and the precipitation of a fine gypsum powder.

MAIN AND ASSOCIATED PROCESSES INVOLVED IN ICE DYNAMICS IN SCĂRIŞOARA ICE CAVE

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Temperature - outside and inside the cave, air moisture and water dripping (influenced by rainfall) are the main factors involved in the development of ice in caves. Given the fact that Scărişoara Ice Cave is a static one, we do not consider the morphology in this case.

Depending on the combination of these factors, processes of melting, freezing and sublimation occurs. In this paper we analyse the importance of these processes, the way they interact and them impact on the dynamics of ice formations and ice block.

ICE CAVES AND ICE FEATURES IN CAVES OF POLISH TATRA MOUNTAINS

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Northern slopes of the Tatra Mountains are well-known of numerous cave systems with the longest and the deepest caves in Poland. Ice features are very common in most of caves during wintertime, forming in near-entrance parts differentiated in scale and morphology assemblages. In this group the following types of ice occurrence are distinguished: ice flakes and crystals, ice stalactites, ice stalagmites, ice columns, ice varnish, ice tile on stagnant or flowing water, ice fibers and lenses on the surface or within cave sediments. In some caves located in the range of altitudes between 1250 and 1916 m a.s.l. climatically and morphologically conditioned masses of perennial ice also exist. Observed ice features present seasonal evolution, ice structure and chemistry depending on changes of thermal and hydrological conditions. The particular attention is given to the largest ice cave - Jaskinia Ladowa w Ciemniaku and to Jaskinia Magurska, which hosts rich, but only seasonal ice.

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